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BACTERIAL FRUITLET BROWN-ROT OF PINEAPPLE IN THE PHILIPPINES [1]

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NINETEEN PLATES AND ONE TEXT FIGURE

THE DISEASE

HISTORICAL

This disease was first noted by the writer during the latter part of June, 1924, when fruits of the Smooth Cayenne variety [2] were examined and found infected. Isolations made from the specimens yielded a primuline yellow bacterium and a species of *Penicillium*. Because of lack of the necessary materials, owing to the close of the pineapple season, and because no complaint was received the following year, the investigation was not resumed until towards the latter part of May, 1926, when further diseased Smooth Cayenne fruits were secured from Calauan, Laguna Province, Luzon. Since the disease was ap-

[1] The writer is grateful to Dr. C. J. Humphrey, mycologist and plant pathologist in charge, Bureau of Science, for his valuable advice and criticisms during the progress of the work; to the organic chemistry division of the Bureau of Science for the analysis of the fruits; to the inorganic chemistry division, Bureau of Science, for the hydrogen ion determinations; and to Messrs. E. Cortes and M. Ligaya, photographer and illustrator, respectively, of the Bureau of Science, for aid in the preparation of the illustrations.

[2] From the Lamao Experiment Station of the Bureau of Agriculture, and from Mr. M. Lichauco, a pineapple planter in Tayug, Pangasinan Province, Luzon.

parently quite serious, especially at Calauan, it was then decided to continue the investigation with the view of determining its true nature and working out a feasible means of control.

GEOGRAPHICAL DISTRIBUTION

The disease seems to have a general distribution in the central and southern provinces of Luzon, particularly in Pangasinan, Bulacan, Bataan, Cavite, Laguna, and Batangas. Further survey may also reveal the disease in other parts of the Archipelago, since the three leading and commonly grown native varieties of pineapples (Costa, Pula, and Puti) are also affected, although none of them suffer as heavily as the Smooth Cayenne.

In 1898, Tryon (13) reported from Queensland a disease of pineapple he called "fruitlet core-rot" which resembles in many ways the disease under discussion. The Prickly Queen was found by him to be more severely attacked than the Smooth Cayenne. He claimed that a red mite (*Tarsonemus ananas*), found in abundance in the eye cavities of diseased fruits, originated the disease, although a species of *Monilia*, allied to *Monilia candida*, was considered a secondary factor, this fungus entering the fruits through injuries made principally by the mites, but in some instances by mealy bugs and thrips.

During the summer of 1924 Barker (1) reported a disease at Cap Haitien, Haiti, that affected 50 to 75 per cent of Smooth Cayenne fruits. This disease, which he calls "fruitlet black rot," appears from the description to be quite similar to the Philippine bacterial fruitlet brown-rot if not identical with it. Barker claims that a pale yellow bacterium, which has been constantly isolated from affected fruits, would produce the disease when inoculated under aseptic conditions into sound maturing fruits. In as much as no description of the casual bacterium was given, comparison with the Philippine organism is not possible.

SYMPTOMS

External signs of the disease.—The disease is very difficult to diagnose without cutting the fruits. When the infection is only slight to moderate no external signs that may indicate unhealthiness are visible (Plate 1). With very severe infections, however, the ripening color may be distinctly dull and often marked with minute purplish dots. Greenish patches may also

occasionally be present, producing the appearance of uneven ripening. If such sickly-looking fruit be extraordinarily hard, which can be noted by pressing with the hands, it is safe to declare it a total loss (Plate 2). These characteristics, however, may easily be overlooked.

Malformations and gummosis, on the other hand, are not significant characteristics of the disease.

Internal signs of the disease.—Diseased fruit when cut open reveals one or many (sometimes all) affected fruitlets in which there are brown [3] to dusky brown or bone brown spots and patches, depending apparently on the stage of infection. In young infections the color is brown, turning to dusky brown and finally bone brown with age. In general the discoloration appears to originate in the placentæ where the three slits or fissures running down from the base of the three alternate stamens end their course. Thence it extends as brown to dusky brown, more or less granular, radiations into a limited portion or to all of the inner surfaces of the individual fruitlets; in the latter case the entire fruitlet may be thoroughly blackened.

The affected tissues are at first as juicy and soft as the healthy ones, but as the disease progresses they become dry and hard, so much so in fact that in advanced cases infected fruits can be distinguished by their resistance to cutting. The disease appears to be a rot of the fruitlets rather than a general rot of the entire fruit, a characteristic which may be noted even in the severer cases of infection. It develops only during the process of ripening and does not seem to spread after ripening or during storage. In green or immature fruits rarely can any trace of the disease be found.

In many instances the disease does not appear to affect the connective tissues, although occasionally the fibrovascular bundles in the core of the fruits are distinctly browned (Plate 3). This discoloration, however, can always be traced to the diseased fruitlets. The browning of the fibrovascular bundles in the core seems to be invariably associated with the hardened condition of severely infected fruits.

This disease must not be confused with several somewhat similar but less serious fruitlet spots or fruit rots that occasionally occur in pineapples.

[3] The colors indicated here and elsewhere in this paper are those of Ridgway's Color Standards and Color Nomenclature. Washington (1912).

ECONOMIC IMPORTANCE

Observations made on four hundred forty-seven fruits, including both Smooth Cayenne and native varieties, from Calauan, Laguna Province; Abukay, Bataan Province; Silang, Cavite Province; and Guiguinto, Bulacan Province, showed that an average of 42.4 per cent of them were diseased. Of the native varieties examined (Costa, Pula, and Puti) 33 to 62 per cent were infected; the total loss, however, was slight. As high as 54.4 per cent of the Smooth Cayenne fruits from Calauan were found to be infected, slightly less than one-third of these (17 per cent) being a total loss (Table 1). Moreover, information from reliable sources indicates that the disease was even worse in 1926 than in 1927.

TABLE 1.—*General pathological observation on Smooth Cayenne and native pineapple fruits from Luzon.*

Source of data.	Healthy.	Slightly infected.	Moderately infected.	Total loss.	Diseased.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Calauan; 147 Smooth Cayenne	45.6	37.4	15.0	2.0	54.4
Abukay; 96 Smooth Cayenne	58.3	35.4	4.2	2.1	41.7
Silang; 44 Smooth Cayenne	86.4	13.6	0	0	13.6
Silang; 50 Pula	48.0	52.0	0	0	52.0
Silang; 50 Puti	38.0	62.0	0	0	62.0
Guiguinto; 30 Costa	60.0	40.0	0	0	40.0
Guiguinto; 30 Puti	66.7	33.3	0	0	33.3

THE CAUSAL ORGANISM

ISOLATION

From diseased Smooth Cayenne fruits from Calauan hundreds of cultures [4] were made weekly during the pineapple season of 1927 by transferring discolored blocks of diseased tissue to tubes of glucose bouillon +10 (Fuller's scale). As soon as cloudiness appeared in the bouillon, generally after six to twelve hours, dilution plates were made on potato glucose agar +10. In all cases, whether blocks were taken from the discolored thin placental covering, from the ovaries, or from browned connective tissues in the core, pure cultures of the primuline yellow bacterium, often in uniform colonies free from contamination, were obtained.

[4] In all cases the isolations were made from diseased fruits which had been kept in the laboratory not more than two days after picking. Often the work was done on the same day that the fruits were picked.

A species of *Penicillium* which is present in the floral parts in the eye cavity in nine cases out of ten has also been isolated at times when the blocks were taken from the characteristic hard, dry, tumorlike formations at some point along the open channels or fissurelike slits originating at the base of the three alternate stamens in the eye cavity and leading into the placental region. From these infected areas the *Penicillium* was in some cases isolated pure, but usually there were contaminations. In general, fungus infection was rare and usually met with only in the dry hardened parts of the diseased fruits.

In order to find out at what stage the fruit becomes infected, isolations were made at different stages of maturity. All isolations from fruits with flowers still closed gave negative results, while some of those in bloom yielded the primuline yellow bacterium. It was obtained by direct planting, without sterilization, of healthy-looking petals, stigmas, anthers, styles, and stamens of already opened flowers into glucose bouillon +10, some of the cultures showing turbidity after six to twelve hours. In the dilution plates made from these cultures, however, the primuline yellow bacterium was oftentimes associated with other microörganisms. Isolations from browned ovaries (which are quite common in immature fruits with flowers already dried and "eyes" more or less tightly closed), as well as from semimature fruits showing no visible sign of infection internally or otherwise, yielded the same primuline yellow bacterium in pure culture. This would indicate that the pathogen gains entrance into the fruit as early as the blooming period.

This same organism has been isolated from diseased Smooth Cayenne fruits from Bataan, Cavite, and Pangasinan and from native pineapples from Guiguinto, Bulacan Province; Lipa, Batangas Province; and Silang, Cavite Province.

TAXONOMY AND MORPHOLOGY

The pathogen is believed to be a new species and has the following characteristics:

ERWINIA ANANAS sp. nov.[4]

Short rod, with more or less round ends, measuring 0.9 by 0.6 micron; occurring singly and in pairs, but occasionally in

[4] Following the recent proposals by the Society of American Bacteriologists (2, p. 168 and 3, p. 189) this pineapple pathogen is classed under *Erwinia*, and the name *Erwinia ananas* is here proposed. If the classification of either Smith (10) or Migula (7) is followed it should be *Bacillus ananas*.

chains; motile by means of peritrichous flagella numbering from 4 to 8 (shown by both Van Ermengeru's, and Plimmer's(9) method of staining); encapsulated and grouping in clumps at times; nonspore-forming, Gram-negative by Burke's(4) method, not acid fast, staining readily with carbol fuchsin, gentian violet, methyl violet, but faintly with methylene blue. It stains bipolarly with carbol fuchsin but may show opposite reaction when old and degenerating. Paired bacteria, as clearly shown with Zien's carbol fuchsin, generally appear as a single organism with Verhoeff's carbol fuchsin (see Plate 17).

Using the most recent chart prepared by the Society of American Bacteriologists(8, p. 148), the index number is 5311–32125–1222.

CULTURAL CHARACTERS

Potato-glucose agar +10.—After twenty to twenty-four hours plate dilutions at room temperature (25° to 30° C.) produced surface colonies about 3 millimeters in diameter, circular, convex, dense, homogeneous, entire, moist, straw yellow, usually showing "mottling." They became primuline yellow and glistening in forty-eight hours, and when the plate was held in a vertical position some of the colonies ran down over the surface like a tear drop. On the fourth day they doubled in size and produced a butyrous concentric ring; some were umbilicate. After about ten days the colonies showed a tendency to spread, thus forming crenate margins. Deep colonies were elliptical to fusiform, with a straw yellow, granulated thin center (Plate 3). Odor is similar to fermenting tikitiki or molasses.

On slants there were produced at first straw yellow raised streaks which later became primuline yellow, moist, and glistening. Globules ran to the bottom of the tubes after twelve to twenty-four hours. At the lower end of the streak, and in the bacterial mass accumulating at the bottom, a greenish gray to violet-gray color was occasionally observed, while a delicate metallic tint of yellowish blue-violet was generally noted at the surface. The edges of the growth became crenate after five days. Zoöglœalike formations occasionally developed on the lower portion of the streaks.

In stab cultures the bacterium produced a moderate, glistening, straw yellow to primuline yellow growth on top of the agar, filiform within.

Beef-peptone gelatin.—Stratified liquefaction was noted after two days and was complete after five days. At first the liquid

remained clear, with flocculi, but later became turbid, and a deep chrome-colored sediment was deposited. To determine the presence or amount of liquefaction the tubes held at room temperature (25° to 30° C.) were solidified at intervals of twelve hours by cooling for ten minutes at 10° C.

Löffler's blood serum.—After twenty-four hours a streak of moderate growth developed. It was slightly raised, mustard yellow to primuline yellow, and had crenate edges. No liquefaction was noted even after three months.

Beef bouillon +10.—This became turbid within twelve hours, more so after a day, with granular growth on top which developed during the second day into a thin, fragile, straw yellow pellicle with a ring adhering along the sides of the tube. Slight jarring caused the ring to break away and settle to the bottom.

Glucose bouillon +10.—In order to determine the relation of the organism to the amount of available sugar in the medium, which in turn may throw light on its behaviour toward fruits, bouillon was prepared with varying amounts of glucose; namely, 1, 5, 10, 15, and 20 per cent. These concentrations were inoculated, in duplicate, with a loop of one-day-old culture and incubated at room temperature. The results are as follows:

TABLE 2.—*Relation of sugar to growth of the pathogen.*

Glucose.	Growth.				
	First day.	Second day.	Third day.	Fourth day.	Fifth day.
Per cent.					
1	Luxuriant	Luxuriant	Waning	Moderate	Faint.
5	Very luxuriant.	Very luxuriant.	Luxuriant	Luxuriant	Waning.
10	Luxuriant	More luxuriant	Very luxuriant.	Very luxuriant.	Luxuriant.
15	Moderate	Luxuriant	More luxuriant	do	Very luxuriant.
20	Faint	Moderate	Moderate	Luxuriant	Do.

After six hours turbidity in all tubes was noted, with a decreasing intensity from the third lowest concentration to the highest. A thin, fragile, granulated pellicle and straw yellow ring adhering along the sides of the tubes developed after twenty-four hours, becoming slimy after forty-eight hours. As shown in the tabulation the bacterium responds more quickly to a 5 per cent concentration than to higher ones. The solution became sulphine yellow in color.

Litmus milk.—The blue color of the medium began to fade from the top after twenty-four hours and completely disappeared in five days. The reaction was faintly acid at first, later

becoming alkaline; medium coagulated and turbid, with delicate flocculent clots.

Congo red agar stab.—After twenty-four hours scanty growth developed at the top of the puncture, a bluish color appearing on the fifth day along the line of puncture, denoting the formation of free acid. After nine days granular, bluish black, minute specks radiating from the line of puncture and taking a downward course upon hitting the walls of tubes were visible.

Cohn's solution.—No appreciable growth was noted after forty-eight hours or even after ten days.

Omeliansky's nutrient fluid.—Negative even after ten days.

Pineapple plugs.—A copious growth, straw yellow to primuline yellow, developed after twenty-four hours. In four days colonies of varied form arose from the mass on the surface of the plug and later coalesced to form primuline yellow globules of bacterial ooze which settled to the bottom. A delicate metallic tint of yellowish blue-violet was generally observed at the surface.

Sugar-cane plugs.—In forty-eight hours moderate moist slimy growth developed on the surface of the medium. As the medium dried it gradually changed to clay color or snuff brown in the case of Cebu Purple and Hawaii 109, later becoming dusky brown to bone brown with a delicate metallic tint of yellowish blue-violet. No discoloration of Luzon White variety was noted.

Banana plugs.—Yellow, glistening, moist, spreading growth developed after twenty-four hours, with apparent discoloration commencing from the top. In two weeks the plugs were completely discolored from pale olive buff to olivaceous black or fuscous black, with a delicate metallic tint of yellowish blue-violet. The varieties used may be grouped in the order of their susceptibility to color changes as follows: Tondoc, Sabá, Boleró, and Latundan. The discoloration produced here was very similar to that of typically diseased pineapple fruit.

Potato plugs.—Copious, glistening, moist, spreading, homogeneous, primuline yellow to aniline yellow growth developed after about twenty-four hours. No discoloration of the plugs was observed.

CHEMICAL PRODUCTS FORMED

In determining the biochemical activities of the pathogen the methods given by Eyre(5, p. 276), unless otherwise stated, were followed, with slight modification in some instances to suit actual conditions.

Fermentation.—With Dunham's peptone water and Andrade's indicator(12, p. 40) three series of 2 per cent solutions of twenty-

four different substances, principally carbohydrates, were prepared in seventy-two fermentation tubes. Each of the first series was inoculated with a young active culture of the primuline yellow bacterium, designated as A, by introducing into each a loop of the inoculum in water suspension. The second and the third series, respectively, were inoculated in an identical manner, with the primuline yellow bacterium isolated from the native varieties and designated as B, and with a gray strain (supposedly a "mutant" from A) designated as C. The first observation was taken after one day, the second after five days, and the third after ten days. The results are given in Table 3.

TABLE 3.—*Fermenting capacity of the pathogen.*

A. Primuline yellow bacterium from Smooth Cayenne.
B. Primuline yellow bacterium from native varieties.
C. Gray bacterium (mutant?) from A.
a. Bacterial growth both *aërobic* and *anaërobic*, reddening the medium, which becomes acid to litmus paper.
b. Same as "a," but *strongly* acid to litmus paper.
c. Bacterial growth *aërobic* only, reddening the medium, which becomes acid to litmus paper.
d. Same as "c," but strongly acid to litmus paper.
e. Medium not reddened; *alkaline* to litmus paper.

Carbohydrate used.	One day.			Five days.			Ten days.		
	A	B	C	A	B	C	A	B	C
Saccharose	b	b	d	b	b	d	b	b	d
Manite	b	d	e	b	b	d	b	b	d
Raffinose	b	d	e	b	b	d	b	b	d
Glycerine	d	d	e	b	e	d	b	b	d
Salicin	d	d	e	b	b	e	b	b	c
Lactose	b	d	e	b	b	d	cd	cd	c
Dextrin	b	d	d	b	b	d	cd	cd	c
Maltose	b	d	d	b	b	d	a	a	c
Levulose	b	d	d	b	b	c	a	a	c
Mannose	b	d	d	cd	cd	c	a	a	c
Glucose	a	c	c	a	a	c	a	a	c
Sorbitol	c	c	e	a	a	c	a	a	c
Galactose	c	c	c	c	c	c	c	c	c
Arabinose	e	e	e	c	c	c	c	c	c
Xylose	e	e	e	c	c	c	c	c	c
Amygdalin	e	e	e	c	e	e	a	e	e
Rhamnose	e	e	e	e	e	e	e	e	e
Inositol	e	e	e	e	e	e	e	e	e
Inulin	e	e	e	e	e	e	e	e	e
Nutrose	e	e	e	e	e	e	e	e	e
Dulcitol	e	e	e	e	e	e	e	e	e
Adonitol	e	e	e	e	e	e	e	e	e
Asparagin	e	e	e	e	e	e	e	e	e
Amylum	e	e	e	e	e	e	e	e	e

As shown in the first three columns of Table 3, culture A was, in general, the most active within the first 24-hour period, while B was second and C third. After five days practically the same course of events was observed, with B approaching A and C trailing behind. Except with amygdalin where A produced a trace of acid while B did not, the reactions of A and B were identical throughout the series after ten days; that is, both demonstrated power to produce acid from the first fifteen substances, both indicated ability to grow in the absence of free oxygen in the first twelve, and both showed ability to grow in the last eight, apparently with alkali production instead of acid. Culture C demonstrated the same activities as B with the exception that B could apparently grow anaërobically while C could only develop in the presence of air.

The cultures that did not show any red (deep rose) coloration were alkaline to litmus paper on the fifth day. It was also noted that at this time acid production began to subside in some of the cultures. By the tenth day some of them had more or less completely faded out and were alkaline to litmus paper, while sucrose, mannite, raffinose, glycerine, and salicin were still deep rose in color and strongly acid in reaction. It was also noted that no gas was produced in any of the tubes.

In addition to these substances 1 per cent solutions of sodium citrate, sodium lactate, sodium tartrate, and sodium formate in peptone were tested. The three inocula showed moderate growth in all of these cultures except sodium formate, which remained negative even after ten days.

All these results tend to show that A and B are apparently identical, the slight difference in their reactions to amygdalin being perhaps nothing more than a result of host specialization or slight degeneration due to unfavorable environment. It can be seen offhand that C is in essential agreement with the others except with respect to oxygen relations. However, the latter fact, coupled with its apparent inability to produce a yellow pigment, may be sufficient grounds for considering it a different strain or variety.

Acid production.—Following the procedure given in Eyre's pathological technic it was found that the yellow bacterium could produce in twenty-four hours from 100 cubic centimeters glucose bouillon +15, containing 2 grams glucose, approximately 0.00645 gram of acetic acid equivalent to 1.0859 cubic centimeters of 0.1 N sodium hydroxide. The presence of the acid was demonstrated by the unpleasant smell of cacodyl produced when resi-

dues of the distillate were mixed with arsenious oxide in equal parts and heated on platinum foil.

In addition to this the yellow bacterium showed the following characteristics:

Alcohol production.—It has the power to produce a small amount of alcohol and aldehyde, as shown by Lugol's iodine test and Schiff's reagent.

Enzyme production.—It was found to be capable of producing diastase, invertase, and traces of rennin and "lab" enzymes but not protease.

Ammonia production.—It has demonstrated ability to produce a small amount of ammonia, as shown by Nessler's test.

Indol production.—Negative by Rindol reaction.

Phenol production.—Negative by Millon's reagent.

Pigment production.—It was found to produce yellow pigment of different intensities, depending to some extent on the temperature at which the culture was incubated. At 7° to 10° C. it produced a sulphur yellow color which gradually increased in intensity until it became ochraceous yellow when about one month old. At room temperature (25° to 30° C.) the bacterium became primuline yellow in twenty-four to forty-eight hours. On banana plugs it produced a color (olive buff to olivaceous black) quite similar to the color of typically diseased pineapple fruits. In the absence of free oxygen, as in Buchner's tubes, pigmentation was very feeble. Light seemed to favor pigmentation to a slight extent. The pigment dissolves slightly in hot and cold water and in sulphuric acid, but not in sodium hydroxide.

Reduction of nitrates.—In twenty-four hours nitrates were reduced to nitrites, as shown by the brownish red color produced when the culture was treated with sulphuric acid and metaphenylene diamine. The check culture remained negative.

Gas production.—No formation of either carbon dioxide or hydrogen was shown in the fermentation tubes even after sixty days. In lead peptone solution, however, the yellowish white precipitate was converted into brownish black after approximately two weeks' incubation. This would seem to indicate very slight liberation of hydrogen sulphide gas. The control tubes remained practically unchanged.

OTHER PHYSIOLOGICAL CHARACTERISTICS

Relations to oxygen.—The yellow bacterium has shown best growth in the presence of oxygen and only very faint growth

under anaërobic conditions. This power to grow anaërobically (though very faintly) was demonstrated by the pyrogallic acid method in Buchner's tubes.

Reactions to temperature.—It has shown growth on potato glucose agar +10 at a temperature ranging from 6° to 45° C., with an optimum at about 30° to 35° C. In tubes of 10 cubic centimeters beef bouillon +10 it was killed by a ten-minute exposure at 56° to 57° C.

Reactions to media.—It has shown best growth at +10 to +20 (Fuller's scale), the cultures becoming turbid after six hours. Only a trace of growth was observed in the neutral and —10 media, and none at all in either +30 or —20. It would seem that its optimum acidity lies around +15.

Resistance to sodium chloride.—Sodium chloride in small amounts has not shown any deleterious effect on growth. Bouillon tubes containing 1 and 2 per cent, respectively, showed decided turbidity after twenty-four hours, while those containing 3, 4, and 5 per cent were only slightly turbid. After forty-eight hours a thin, creamy pellicle commenced to form on top of the 1 and 2 per cent concentrations, but there was only faint turbidity in the 6, 7, 8, and 9 per cent and none in 10 per cent concentration, even after ten days.

Resistance to desiccation.—It has shown extreme resistance to desiccation. Films of the yellow bacterium were made aseptically on cover slips, placing the preparations in sterile plates as soon as made. The plates were then kept in a desiccator at room temperature. At twelve-hour intervals the cover slips were placed aseptically one at a time into tubes of glucose bouillon +10 to determine the viability of the organism. This procedure was continued for seven days, the organism being alive at the end of the period. Following this, the remaining cover slips were placed in tubes at weekly intervals until the last three successive plantings showed negative results, verified by poured platings. In this manner it was determined that the bacterium could remain alive under desiccator conditions for at least four and one-half months, but not for five months.

Resistance to light.—It proved fairly resistant to direct sunlight, but five hours' exposure (on ice) was fatal (Plate 3, fig. 6). Diffuse daylight in the laboratory did not produce any appreciable effect, except perhaps slightly deeper pigmentation.

Resistance to freezing.—Freezing (—10° C.) for one day has not shown any appreciable destructive effect, two to three days

being necessary to effect degeneration and a slackening of its growth rate, while fifteen days were required to kill. These data were secured by keeping a bouillon tube freshly inoculated with the very young, active, primuline yellow bacterium on the cooling coil in an electric refrigerator at an average temperature of —10° C. Streak cultures were made from this daily on potato glucose agar +10 until three negative results were obtained in succession.

Resistance to disinfectants and sprays.—In order to gain a rough idea of the relative toxicity to the yellow bacterium of copper sulphate, mercuric chloride, and lime-sulphur solution several duplicate tests were made with these substances by mixing them in definite proportion with beef bouillon +10 and inoculating them with a loop from a two-day old culture of the yellow bacterium growing in beef bouillon +10.

The dilutions shown in Table 4 were made as follows: One gram of copper sulphate crystals was dissolved in 10 cubic centimeters of distilled water. From this stock solution 1 cubic centimeter was transferred by means of a sterile pipette to a test tube containing 9 cubic centimeters of sterile bouillon. This gave a concentration in the medium of 1: 100. The next step was to transfer 1 cubic centimeter from the tube so prepared to another tube likewise containing 9 cubic centimeters of sterile bouillon. This gave a concentration of 1: 1,000; the process was continued up to a concentration of 1: 100,000,000.

The dilutions of mercuric chloride were made in a similar manner except the 10 per cent stock solution of the powdered crystals which was prepared by dissolving in hot water.

The lime sulphur was first made up to a gravity of 32° B. and allowed to stand about two days, the clear orange liquid then being decanted. This liquid was then diluted with the bouillon to make concentrations from 1: 10 to 1: 1,000.

One check culture, without the addition of chemical, was prepared for each series of dilutions for purposes of comparison.

Three days after inoculation observations were made and poured plates prepared on potato glucose agar +10 from the tubes free from turbidity. All such tubes gave negative results, showing that the organism was not only inhibited but killed. Positive results were determined without plating, by observing the turbidity of the cultures and the characteristic growth of the organism.

TABLE 4.—*Effect of disinfectants.*

Disinfectant.	Dilution.	Result.	Disinfectant.	Dilution.	Result.
Copper sulphate	1:100	—	Mercuric chloride	1:10,000,000	+
Do	1:1,000	—	Do	1:100,000,000	+
Do	1:10,000	+	Do	Check	+
Do	1:100,000	+	Lime sulphur, 32° B.	1:10	—
Do	1:1,000,000	+	Do	1:20	—
Do	1:10,000,000	+	Do	1:40	—
Do	1:100,000,000	+	Do	1:60	—
Do	Check	+	Do	1:80	—
Mercuric chloride	1:100	—	Do	1:100	+
Do	1:1,000	—	Do	1:250	+
Do	1:10,000	—	Do	1:500	+
Do	1:100,000	—	Do	1:1,000	+
Do	1:1,000,000	—	Do	Check	+

As shown in Table 4, 1: 1,000 copper sulphate, 1: 1,000,000 mercuric chloride, and 1: 80 lime-sulphur solutions were strong enough to kill the bacterium, but greater dilution did not show any considerable effect, as seen from the intensity of turbidity. Therefore, of the three chemical solutions mercuric chloride has shown the most toxic effect and copper sulphate the next.

Vitality in artificial cultures.—The vitality of the organism in artificial cultures was found to depend a great deal on the composition of the media as well as on the environment. Being a sugar-consuming organism, it was found to grow better and remain viable longer on media containing sugar, such as glucose bouillon +10, potato glucose agar +10, etc., than on protein media. Conserving the moisture of the culture by partially sealing the test tube with paraffin and incubating it at room temperature (25° to 30° C.), also lengthened the life of the pathogen. Poured plates made from cultures twelve months old in glucose bouillon +10 and on potato glucose agar +10 have shown that it was still viable (although very much degenerated, as indicated by colonies of varied form and pigmentation).

Degeneration and variation.—Like most other bacterial organisms this bacterium is prone to pass into unusual forms called "degenerates," either as a result of continuous cultivation on artificial media, or incubation under unfavorable environment, or both.

The effect of growing it continuously on artificial culture media was demonstrated by making dilution plates daily for thirty days from a newly isolated culture on potato glucose agar +10

incubated at room temperature. The first visible sign of degeneration was observed on the third day, when one or two olive yellow colonies appeared amongst the primuline yellow colonies. With greater age more-degenerated individuals were noted, these departing so much from the original typical primuline yellow bacterium that the pure culture appeared as if contaminated with a foreign organism. The degeneration was finally such that dilution plates from a one-year-old culture in glucose bouillon +10 showed only about 30 per cent primuline yellow colonies, 30 per cent olive yellow, 35 per cent minute, pale olive-buff (later becoming rugose and umbonate, with olive lake center), and 5 per cent grayish olive with conical surface (Plate 4).

The effect of unfavorable environment upon degeneration was found to be even more decisive and quicker than the results just cited. A culture incubated for a month at 7° to 10° C. has shown as much degeneration as the culture kept for a year in the laboratory at a temperature varying from 25° to 30° C. Such degenerate effect was very clearly observed when three badly diseased fruits were kept in an electric refrigerator at 7° to 10° C. for the same period. From these fruits the typical primuline yellow bacterium was obtained in pure culture in all the plates on the first day (before they were placed in the electric refrigerator) and even after two days; but when dilution plates were repeated on the fifteenth day one yielded a pure culture of uniform, minute, ivory yellow colonies instead of the original primuline yellow, and repeated platings failed to recover the primuline yellow bacterium. On the twenty-third day an identical phenomenon was observed with the second fruit, followed on the thirtieth day by the third. Repeating the isolations from the same materials, forty, fifty, and sixty days after, the same results were obtained. It was noted that the fruit that showed the first transformation of the organism was the smallest, the second was medium sized, and the third was the largest.

In view of the fact that cultures of the primuline yellow bacterium have been found still viable after one month incubation at 7° to 10° C., it seems unbelievable that in fresh pineapple fruit (its natural host) it should die earlier than this and be completely replaced by an ivory yellow organism which had never been met in previous isolations. The results have been thus far uniform, but still the problem seems puzzling and certainly needs further study before a definite conclusion can be safely drawn.

Morphologically, the ivory yellow organism has shown characters seemingly indistinguishable from the primuline yellow one, but in cultural behavior the two differ greatly. While it took four to five days for the primuline yellow strain to completely liquefy peptone gelatin, the ivory yellow one completed it in two days; and unlike the primuline yellow strain it showed a preference for invert sugar over saccharose, as shown by its good growth in the former and decidedly feeble growth in the latter. The ivory yellow organism also proved to be an obligate aërobe and produced no acid in fermentation tubes of different sugars, even after ten days.

At room temperature colonies of the ivory yellow bacterium on plates of potato glucose agar +10 are at first minute, opalescent, convex, circular, entire, becoming ivory yellow, wrinkled, with crenate margins after two or three days, then finally becoming round, creamy, wet, glistening, pulvinate to hemispherical, free from wrinkles, abundant after five to six days, and diffusing a pale green-yellow color into the agar. At 7° to 10° C. the colonies were very small and poorly developed.

A pearl gray to deep green-blue gray strain which may perhaps be considered a "mutant" or "sport" was occasionally isolated from two- to three-week cultures on potato-glucose agar +10. This gray organism might be considered identical with the primuline yellow organism were it not for the difference in their color and their relations to oxygen, the former having lost the power to grow in the absence of free oxygen, thus becoming an obligate aërobe while the yellow organism remains a facultative anaërobe. Moreover, unlike the primuline yellow organism, it has shown a considerable degree of stability and no tendency to revert, an important criterion, according to Jordan,(6, p. 122) for designating a "mutant." Platings and replatings from a year-old culture of this, and hundreds of test tube transfers made therefrom, gave uniform results, thus proving its permanence under ordinary conditions (Plate 4).

PATHOGENICITY: INOCULATION AND REISOLATION EXPERIMENTS

In the laboratory.—On June 26, 1926, the first set of preliminary inoculations was made in the laboratory. Eighteen fresh, 2-kilogram, apparently healthy, fully mature Smooth Cayenne fruits just showing very faint signs of ripening were selected and inoculated by needle punctures with five-day-old pure cultures of the primuline yellow bacterium and *Penicillium* sp. grown on potato glucose agar, +10. The fruits were first

washed with tap water to free them from dust, and when dry the surfaces were disinfected with 1:1,000 mercuric chloride in 70 per cent alcohol. On one side of each of the first six fruits six fruitlets were punctured with a needle previously sterilized in the flame of an alcohol lamp. Into these punctures were introduced by means of another sterile needle a pure culture of the primuline yellow bacterium. Another set of six fruits was inoculated with the *Penicillium.* The remaining six serving as a check were punctured without introducing any inoculum. In each case care was exercised that no puncture passed the eye cavity, thus avoiding contamination with various organisms generally present therein. The punctures were then coated with paraffin to prevent the entrance of outside organism; later, the inoculated fruits were set aside on a table in the laboratory for fifteen days, after which they were opened for observation.

All fruits inoculated with the primuline yellow bacterium showed light but characteristic lesions, while the checks remained negative; those inoculated with *Penicillium* were questionably positive. The results, therefore, strongly indicate: first, that the fruitlet brown-rot disease can be reproduced by artificially infecting healthy, mature Smooth Cayenne fruits with a pure culture of the primuline yellow bacterium by means of needle punctures (Plate 5) ; second, that, although the *Penicillium* could cause discoloration when inoculated into the fruitlets, the lesions produced thereby were far from being typical of the fruitlet brown-rot (Plate 6).

From positive inoculations the original primuline yellow bacterium and the *Penicillium* were both easily recovered by reisolation.

On June 7, 1927, the preceding experiment was repeated, following exactly the same procedure and technic, except that ripe fruits were used instead of mature ones. The purpose was to find out the relation of the stage of maturity or ripening to the virulence or pathogenicity of the causal organism.

Results quite different from the preceding were obtained from this series. With the exception of the two inoculations with the yellow bacterium, which were not decisive, all the bacterial inoculations gave negative results in spite of the fact that the original bacterium was still alive at the time of examination, as shown by reisolations. The control punctures were all negative, while those inoculated with *Penicillium* were all

questionably positive, although not by any means typical of the fruitlet brown-rot lesions. These results would seem to indicate that certain metabolic processes in the course of development of the fruit, probably taking place during the maturing to ripening stage, exercised some influence upon the power of the organism to cause the disease. This may perhaps explain the writer's observation that the disease has not shown a tendency to advance in storage.

In the field.—Series I. The first field tests were conducted in a plantation at Calauan, Laguna Province, Luzon, on February 14, 1927. Inoculations were made in the following manner: Four uniform, alternate rows of about sixty plants each were selected. With a compressed-air sprayer the first row was sprayed with tap water alone; the second, with a water suspension of the primuline yellow bacterium (5 days old); the third, with a water suspension of the spores of *Penicillium* sp.; and the fourth, with a water suspension of both organisms combined. This was repeated weekly for the two months covering the blooming period (February 14, 1927, to April 4, 1927). In all cases care was exercised to spray the fruits thoroughly.

The fruits from each row were harvested separately as they ripened, and brought to the laboratory for observation. Each fruit was sliced into cross sections about 1 centimeter thick, and the number and the severity of infections therein were noted. The fruits thus examined were marked as "Healthy" when they were absolutely free from any visible characteristic infection; "Slightly infected," when not more than six of their fruitlets were badly infected or not more than ten slightly infected, or, in case deep and shallow infections were both present, the number was not half as many as the two combined; "Moderately infected," when the infection was more severe than the preceding; and "Total loss," when it was so severe that the entire fruits were unfit for table use. The results of these observations are given in Table 5.

As high as 75.7 per cent of the fruits sprayed at the blooming period with a water suspension of the pathogen became infected, while those sprayed with *Penicillium* showed only 35.5 per cent. Those sprayed with the two organisms combined gave 71 per cent, while the control (sprayed with tap water alone) sustained an infection of 36.1 per cent. Such positive results in the check may be attributed to the natural infection which ordinarily occurred under field conditions.

TABLE 5.—*Results of field inoculations, Series I.*

Sprayed with—	Fruits examined.	Healthy.	Diseased.			
			Slightly infected.	Moderately infected.	Total loss.	Total infected.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Tap water only	36	63.9	16.7	16.7	2.7	36.1
Yellow bacterium	37	24.3	24.3	29.7	21.7	75.7
Spores of *Penicillium* sp.	31	64.5	16.1	12.9	6.5	35.5
Yellow bacterium and *Penicillium* sp.	31	29.0	16.1	38.7	16.2	71.0

It will be seen from the same data (Table 5) that although inoculation with *Penicillium* did not in any way increase the number of fruits infected, still the percentage of total loss (6.5) was nearly two and one-half times as high as in the controls (2.7). This, coupled with the writer's experience that all very badly diseased fruits which were dry and hard have shown at the same time the unfailing presence of *Penicillium* in many lesions would seem to indicate that its presence increased the damage to the fruitlets.

More striking still is the fact that despite the heavy artificial infection secured by spraying a water suspension of the pathogen upon the fruits during the blooming period (which is considered as the susceptible stage of the fruits) an average of 26.7 per cent of fruits from the two inoculated rows were absolutely healthy and free from any sign of infection, while some were very resistant, showing but one or two infections. It may be supposed, therefore, that certain individuals possess a considerable degree of immunity to this particular disease. This apparent immunity may be of great significance in devising a permanent means of control.

Series II. The second inoculations in the field were made on March 21, 1927, in the same plantation at Calauan. Thirty uniform mature Smooth Cayenne fruits of about 3 kilograms each were selected and tagged. The surface (facing the east) of each fruit was sterilized with a 1: 1,000 solution of mercuric chloride in 70 per cent alcohol and as soon as dry a puncture on each of six fruitlets, on a vertical line from top to bottom, was made with a sterile needle, taking care to prevent the needle from passing through the eye cavity. Into these punctures were introduced with a sterile needle a pure culture of the primuline yellow bacterium 4 days old; then all punctures were sealed

immediately with a paraffin coating to prevent the entrance of external organisms. Using this procedure and technic nine fruits were inoculated with the yellow bacterium, the next ten with the gray bacterial strain, and the last ten were left without inoculum to serve as check.

Observations were made about a month later. All inoculations with the primuline yellow bacterium as well as the grav strain (supposedly "mutant") were positive, while all the control punctures, with the exception of one fruit which apparently had a uniform natural infection, were negative. It was observed, nevertheless, that the lesions produced by the gray strain were not as distinct and characteristic as those caused by the original primuline yellow organism.

Series III. With the same number and kind of fruits and the same method and technic a third series of inoculations was made on April 4, 1927, using both the *Penicillium* sp. and the primuline yellow bacterium.

All the bacterial inoculations were positive and tend to confirm those obtained from the first of the laboratory inoculations, therefore pointing to the conclusion that it is the primuline yellow bacterium and not *Penicillium*, with which it has in some instances been found associated, that is responsible for the trouble. Three of the fruits inoculated with *Penicillium* also showed characteristic bacterial lesions in some of the punctures; one of the controls also developed bacterial lesions, all of which may be considered chance infection.

Series IV. In order to find out the effect of the age of the casual bacterium on its virulence or pathogenicity, further inoculations into mature fruits, using 40-day-old cultures instead of 4-day-old ones (Series II) were made on April 11, 1927.

Observations were made about a month and a half after. While the results obtained from this series have proved beyond reasonable doubt that the primuline yellow bacterium as well as the gray strain can reproduce the fruitlet brown-rot disease when introduced by needle punctures into the fruitlets, yet there are indications that old age causes a decrease in the pathogenicity of the organisms as shown by the five negative results, three from the gray and two from the yellow out of a total of thirty inoculations. This is paralleled by the fact that in artificial culture media, even under ordinary conditions, the pathogen gradually loses its power to produce acid and to utilize saccharose, as already mentioned.

Another interesting phenomenon observed in this series is that in a number of reisolations from the positive inoculations with the gray strain both the gray and the primuline yellow organisms were obtained. Whether this was due to a chance contamination, to natural infection of the fruit with the yellow strain, as has been the case with other inoculations carried out under the same field conditions, or to a reversion of the gray strain to the original primuline yellow bacterium only further tests can determine.

Results from laboratory and field inoculations would seem to indicate that the incubation period of the pathogen ranges from about fifteen to thirty days.

PATHOLOGICAL ANATOMY

In cutting thin slices of diseased fruits the discoloration or browning in the fruitlet, as well as the occasional browning of the connective tissues in the core, can readily be traced backward to the placental region (Plate 7). Thence, if search be carried farther, connections will be found either with the style or with the fissures or open channels running down from the base of the stamens. This indicates that the pathogen probably gets into the fruit through the flower parts during the blooming period.

It may be presumed that the germs fall by chance on the stigma or anthers (Plates 8 and 10), whence they pass downward into the style or stamens as the flowers dry out, then down into the placental cavity of the fruitlet. Positive isolations from these parts have confirmed these views. Then as the fruit matures and accumulates more sugar the infection spreads much more rapidly in a more or less radial manner, but limiting itself to the fruitlet in the majority of cases, although sometimes running down into the vascular bundles of the core, a characteristic which seems to be almost always associated with dry, hard, severe infections. In some instances, however, the disease may extend through the thin membrane of the placental region into the adjacent fruitlet (Plates 9 to 14).

It has been observed that infection takes place through ruptures of the open channels or fissures (three in number) running from the eye cavity downward into the placental lobes (Plates 10 to 12) or through the mechanical cracks generally present at the base of the three alternate stamens (Plate 7). The cause of these ruptures is not definitely known. In any

case the line of tissues connecting the stamens and the slits or fissures with the ovaries generally shows discoloration (Plate 11), accompanied by extracellular or intracellular bacterial masses in the discolored tissues (Plate 13).

Generally the infected cells are intact, with their contents apparently partly consumed by the bacteria, which usually congregate along the cell wall (Plate 13).

INFECTION OF SUGAR CANE BY THE PINEAPPLE ORGANISM

As the pathogen is a sugar-consuming type, it seemed reasonable that it could also infect sugar cane under favorable conditions; therefore, on July 28, 1927, inoculations were made by two needle punctures in young, tender internodes of mature canes of each of the fourteen varieties indicated in Table 6. The surfaces of the internodes were first sterilized with mercuric chloride solution in alcohol (1: 1,000) before puncturing. After inoculation, paraffin was applied to protect them from outside organisms. Control punctures were made with a sterile needle on canes of practically the same age and treated similarly. On August 30, 1927, they were harvested and each cane was cut longitudinally into halves through the punctures.

TABLE 6.—*Infection of fourteen varieties of sugar cane, arranged in order of susceptibility.*

Variety name.	Results.	
	Inoculated.	Control.
Luzon Purple	Red streaks in 5 nodes	Negative.
Hambledon	do	Do.
Big Tanna	do	Do.
Hawaii 109	do	Do.
Negros Purple	Red streaks in 4 nodes	Do.
Cebu Purple	do	Do.
Guru	do	Do.
Yellow Caledonia	do	Do.
Barbados	do	Do.
Java 247	Red streaks in 3 nodes	Do.
Badila	do	Do.
New Guinea 24-A	do	Do.
New Guinea 24-B	Red streaks in 2 nodes	Do.
Rose Bamboo	do	Do.

As given in Table 6, all cane varieties tested became infected to a greater or less degree. In the length and the number of red streaks and the extent of discoloration running radially

from the punctures (Plate 15) the individual varietal ability to resist the disease differs greatly. In many respects the red streaks produced by the activities of the pineapple parasite in the vascular bundles of the cane resemble those produced by the cane diseases known as "red vascular bundle disease," "gummosis," "sereh," or "leaf scald," the true cause or causes of which are not very definitely known.

The original organism with some degenerated colonies was recovered by reisolation from the red streaks far from the punctures; for example, in adjacent internodes.

With favorable conditions obtaining, sugar cane may therefore be infected by the fruitlet brown-rot pathogen and hence may possibly serve as an intermediate host.

EFFECT OF THE DISEASE ON THE CHEMICAL COMPOSITION OF THE FRUITS [6]

The changes in the chemical constituents of the fruit depend on the extent of infection. These were determined by analyzing representative samples of sound and diseased fruits for Brix, acid content, protein, and sugar.

TABLE 7.—*Comparative analyses of sound and diseased Smooth Cayenne fruits, using the entire fruit.*[a]

Sample.	Brix of juice corrected to 27.5° C.	pH value.	Protein.	Sugars.		
				Sucrose.	Reducing.	Total as invert.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*
Sound [b]	15.93	3.61	0.39	8.27	4.14	12.84
Diseased [c]	12.98	4.30	0.32	7.83	2.60	10.84

[a] Ten healthy and ten diseased ripe fruits showing general yellowing of one-half from the base.

[b] Entirely free from infection.

[c] Moderately infected.

Table 7 shows that diseased fruits contain less sugar, protein, and acid than the healthy, indicating that the pathogen consumes all of the three constituents, with preference for sugar. Repetition of the analysis on diseased and healthy parts of the same fruits gave results tending in the same direction (Table 8).

[6] All chemical and hydrogen ion determinations herein recorded were made by the divisions of organic and inorganic chemistry, Bureau of Science.

TABLE 8.—*Comparative analyses of diseased Smooth Cayenne fruits with healthy parts separated from affected parts.*[a]

Sample.	Brix of juice corrected to 27.5° C.	pH value.	Protein.	Sugars.		
				Sucrose.	Reducing.	Total as invert.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*
Healthy parts	15 66	4.30	0.38	8 96	4.13	13 57
Diseased parts	13.39	4.45	0 37	7 82	4 06	12 29

[a] Composite sample of ten diseased ripe fruits.

DISEASE RESISTANCE

Individual pineapple plants thoroughly sprayed weekly during the blooming period with a water suspension of the pathogenic bacterium vary greatly in their ability to resist or withstand the disease; some seem to be specially predisposed to attack, others are relatively immune.

In the case of both native and introduced pinapples the opening of the "eyes," the relative thickness and early or delayed lignification of the covering of the eye cavity may play an important part in aiding or hindering the penetration of the bacteria. Native pineapples, in spite of their greater percentage of infection, due, perhaps in part, to loosely closed "eyes," sustain less damage from the attack. Comparative analyses [7] of these native varieties, as given in Table 9, show that their sugar content on the average is more than 2 per cent less than that of Smooth Cayenne (Tables 7, 9, and 10). They contain, however, more protein and acid. The chemical composition may, therefore, be one reason why the native fruits suffer less damage from the disease.

Another reason may be that the Smooth Cayenne pineapple is much more juicy than the native varieties; according to Smith (11, p. 12) juiciness in plants is one of the factors favoring bacterial infection. Size of fruits seems also to have an effect, since the heavier fruits are the more severely infected. This may be due to the larger fruits having the tissue-covering of their eye bowls usually less completely lignified, as shown by the mechanical cracks frequently found in them. Such imperfect lignification may be due perhaps to rapid growth of the host, enhanced by favorable conditions of climate and soil.

[7] In all analyses, unless otherwise stated, each sample consisted of twenty ripe fruits.

TABLE 9.—*Comparative analyses of native pineapple varieties from Silang, Cavite Province, and Guiguinto, Bulacan Province.*

Sample.	Brix of juice corrected to 27.5° C.	pH value.	Protein.	Sugars.		
				Sucrose.	Reducing.	Total as invert.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*
Pula [a]	12.71	3.90	0.48	7.01	3.11	10.49
Puti [b]	13.48	4.30	0.49	7.66	3.51	11.57
Costa [c]	10.87	3.80	0.50	6.08	3.19	9.59
Puti [d]	10.94	3.90	0.49	6.16	3.13	9.61
Average	12 00	3.97	0.49	6.72	3.23	10.32

[a] Cylindrical, reddish yellow, with small eyes.
[b] Barrel-shaped, greenish yellow, hard, with large eyes.
[c] Cylindrical, reddish yellow, with small eyes.
[d] Barrel-shaped, greenish purple, with large eyes.

In this connection, changes in chemical constitution during the growth of the fruits may throw some light on their behavior toward infection. Table 10 presents data on Smooth Cayenne fruits at four stages of development.

TABLE 10.—*Comparative analyses of Smooth Cayenne fruits at four stages of development.*

Sample.	Brix of juice corrected to 27.5° C.	pH value.	Protein.	Sugars.		
				Sucrose.	Reducing.	Total as invert.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct*
Immature [a]	7.21	4.24	0.52	1.25	2.55	3.85
Semimature [b]	7.32	3.89	0.40	3.06	2.55	5.79
Mature [c]	10.34	3.51	0.39	4.58	2.63	7.50
Ripe [d]	15.52	4.07	0.39	7.49	4.84	12.73

[a] Two months old (with an average diameter of about 9 centimeters).
[b] Three months old (with an average diameter of about 11 centimeters).
[c] Four and one-half months old (with an average diameter of about 14 centimeters).
[d] Five and one-half months old (with an average diameter of about 15 centimeters).

It will be noted from Table 10 that sugars, particularly sucrose (cane sugar), increase during the development of the fruit, and that in the immature stage the quantity present is comparatively small. On the other hand, protein diminishes in quantity as the fruit becomes maturer. Acid production of the fruit, as shown by the determinations of the citric acid equivalent, seems to be greater during the maturing stage, but the amount present does not appear sufficient to cause much change, if any, in the behavior of the pathogen.

Among other conditions that may render the fruit more or less liable to infection temperature may be considered. It is said that the pineapple grows better in a tropical climate than in a temperate one. The primuline yellow bacterium likewise grows more luxuriantly at a rather high temperature, 30° to 35° C. being its optimum.

In order to compare the internal temperature of the pineapple fruit with the surrounding atmosphere (both exposed and shaded) and with the soil at different times of day at Calauan and Silang a mercury thermometer was thrust 15 centimeters into the middle of a maturing pineapple fruit, another was suspended nearby in the air about 75 centimeters above the soil, a third was inserted to a depth of 15 centimeters in the soil, and a fourth self-recording hygrothermograph was placed under a shed with free circulation of air. Readings were made every two hours from 6 a. m. to 6 p. m. at both places over an interval of ninety days. The corrected computations are plotted in text fig. 1.

From these graphs it will be seen that the temperature in the pineapple fruit is practically the same as that of the atmosphere exposed to the sun; in the shade it is lower. The soil temperature is the lowest, and also the most uniform.

It is said that in 1926 the disease was severe in all the provinces of Luzon where the Smooth Cayenne variety is grown. The relative high temperatures that prevailed during the summer months of that year as reported for Manila by Rev. Miguel Selga, director of the Philippine Weather Bureau, may perhaps account for the serious outbreak.

SURVIVAL AND DISSEMINATION OF THE PATHOGEN

The pathogen can perhaps persist in the soil from the end of the picking season to the succeeding blooming season (August to January), and then live as a parasite in the fruits from February, when most of the plants begin to bloom, to July, when the picking season ends.

Diseased fruits, which are abandoned to rot in the field, may assist the pathogen in living over and are certainly a great source of infection. Slips, suckers, and crowns obtained from diseased fields may also possibly spread the disease to new fields if not given proper treatment to destroy the organisms.

The pathogen may also be disseminated by wind, dashing rain, and insects. It was found that the pathogen was present in the air and the soil in the plantation at Calauan. This was de-

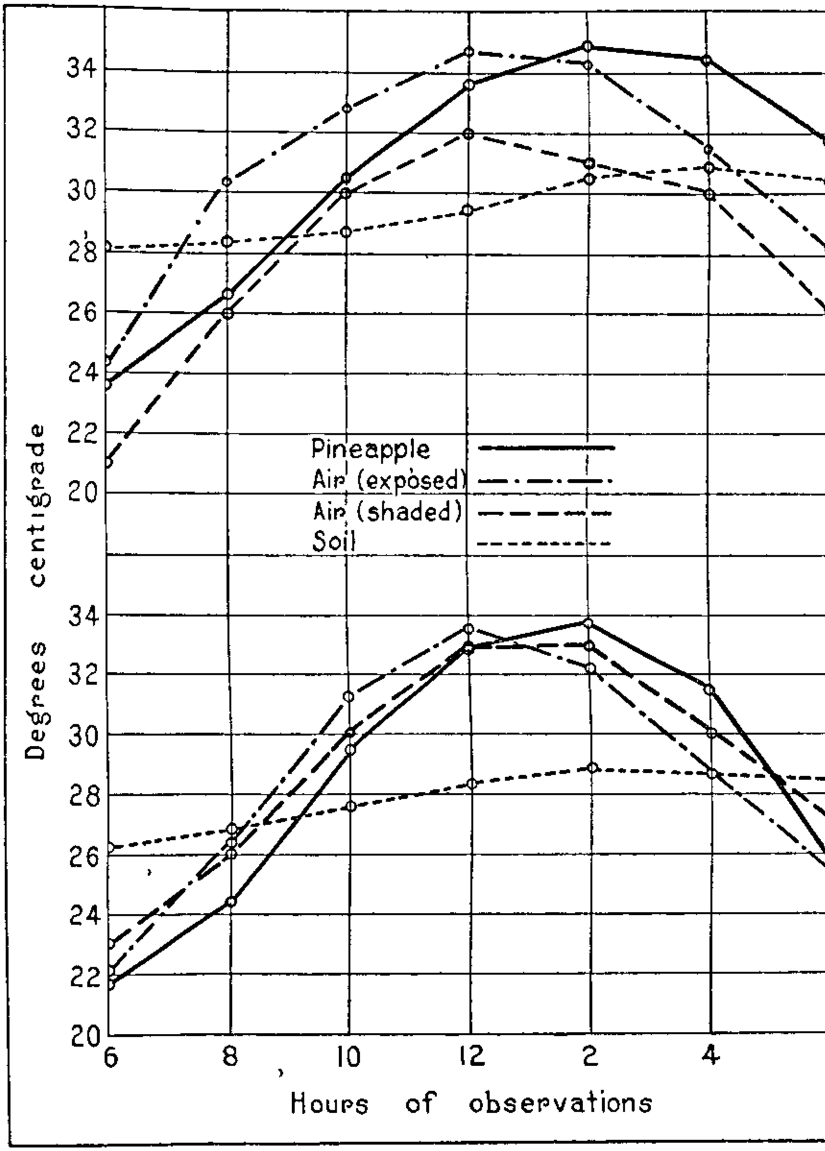

FIG. 1. Temperature studies. Graphs representing temperature relations (from 6 a. m. to 6 p. m.) between the pineapple, the soil, and the environment in correlation with the prevalence of the disease. Upper graph from data collected in Calauan, Laguna Province; lower graph from Silang, Cavite Province.

termined by exposing several agar plates for an hour among pineapple plants in bloom. A water infusion of several samples of surface soil obtained near the bases of the pineapple plants also yielded the organism. It was found also that red

mites, mealy bugs, thrips, and ants, which are sometimes found in the crevices of the fruit, especially in the eye cavities, usually carry the pathogen, together with several other microorganisms, on their feet. There is, therefore, a possibility that the germ may be introduced into the plant by any one of these means. Again, the injuries they cause to the eye bowls and other parts of the flower will naturally help to facilitate infection by the causal bacterium as well as by other secondary organisms that might also be present at the time.

Experiments looking toward the control of the disease are under way.

SUMMARY

1. A bacterial fruitlet brown-rot disease of the pineapple hitherto unreported from the Philippines is described. The disease is not as serious on the native varieties as on the Smooth Cayenne. It is more or less generally distributed in Bataan, Bulacan, Cavite, Laguna, and Pangasinan Provinces, Luzon.

2. The disease is very difficult to diagnose without cutting the fruit. Slight to moderate infections cannot be detected externally. Severe infections, however, show a distinct dull ripening color generally marked with minute purplish black dots. Such fruits appear to be extraordinarily hard.

The disease may be characterized by the brown, dusky brown, or bone brown discoloration of one or more of the fruitlets. Such discolorations may be limited to the placental area or may involve the entire fruitlet; occasionally they extend to the fibrovascular bundles of the core, a characteristic which appears to be invariably associated with the hardened condition of severely diseased fruits. In this type of infection dryness of the tissues is also apparent. All infected tissues are found more or less filled with bacterial masses.

3. The average percentage of infected fruit from Calauan, Abukay, Silang, and Guiguinto was 42.4. Smooth Cayenne fruits from Calauan alone had as high as 54.4 per cent, slightly less than one-third (17 per cent) being a total loss.

4. The disease can be reproduced by artificial infection with a primuline yellow bacterium, designated *Erwinia ananas* sp. nov., with or without previous injury to the fruits.

5. The fruits are susceptible to natural infection only during the blooming stage. The pathogen penetrates through the floral parts and through mechanical cracks or fissurelike slits in the eye cavity. Owing to lack of sufficient food during the

immature stage of the fruit, the bacterial parasite remains more or less inactive before maturity. As the fruits begin to ripen, however, the disease becomes manifest by the discoloration of the invaded tissues.

6. Since the pathogen lives mainly on sugar, although using up some acid and protein, diseased fruits contain relatively less of these substances than healthy ones.

7. Warm weather favors severe infection. The rapid succulent growth of large fruits apparently increases their susceptibility to attack.

8. The pathogen can produce red streaks in sugar cane when inoculated through needle puncture. There is a possibility, therefore, that sugar cane may harbor the disease when favorable conditions obtain.

9. The disease may be spread by wind and dashing rain, by infected fruits, crowns, slips, and suckers from diseased plantations, as well as by red mites, mealy bugs, thrips, and other insects that flit from plant to plant.

10. The red mites are not in any way associated with the production of the disease except perhaps in the dissemination and penetration of the pathogen.

The causal organism, *Erwinia ananas* sp. nov. is described as a short rod, with more or less rounded ends; occurring singly and in pairs, but occasionally in chains; motile by means of peritrichous flagella; nonspore-forming; Gram-negative; facultative anaërobe; variable, and producing abundant yellow growth on natural as well as artificial culture media, but with preference for sugar. Numerous physiological reactions are described.

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ILLUSTRATIONS

Plate 1

A healthy looking, 4-kilogram Smooth Cayenne fruit, showing severe infection within. About ⅓ natural size.

Plate 2

Fig. 1. An unhealthy looking, 4-kilogram, Smooth Cayenne fruit with dull, uneven ripening color, sparingly dotted with purplish spots, and with an extraordinarily hard consistence. More than 0.5 natural size.

2. Longitudinal section showing a more or less thorough infection and with discoloration extending into the vascular bundles of the core. More than 0.5 natural size.

Plate 3

Erwinia ananas sp. nov., plate cultures showing colonies of different ages.

Fig. 1. Colonies 24 hours old with straw yellow color. × 5.

2. Colony 24 hours old showing "mottled" primuline yellow color. The bacterial mass ran down when the plate was held in a vertical position for photomicrographing. × 40.

3. Colonies 3 days old, some umbilicate and some convex, with primuline yellow center and straw yellow margins. × 1.

4. Colonies 5 days old with primuline yellow center and butyrous concentric ring. Note the small elliptical to fusiform deep colonies. About 1⅓ natural size.

5. A 15-day-old colony photographed from below to show characteristic markings and crenate margins. About 7 times natural size.

6. *Erwinia ananas*, agar plate culture, 4 days old, exposed on ice to direct noon sunlight (June 29, 1926) for five hours, with the lower half covered with black paper. Note that practically all of the exposed colonies were killed and most of those that survived were at the bottom of the plate and partially protected by a layer of agar. Taken four days after. About ⅔ natural size. All cultures exposed for less time showed practically no effect.

Plate 4

Erwinia ananas, agar plate cultures, showing degeneration and variation.

Fig. 1. Subculture 6 days old taken from 15-day agar slant, showing two branching colonies such as were occasionally observed. About natural size.

FIG. 2. Subculture 6 days old taken from 1-year agar slant, showing colonies of varied form and color (primuline yellow, straw yellow, olive yellow, sulphine yellow, ivory yellow, pale olive buff, olive gray, etc.). About natural size.

3. Subculture 3 days old taken from colony "x" of fig. 2, showing minute, uniform, pale olive buff, conical, more or less rugose colonies with crenate margins. About natural size.

4. Same as fig. 3 but enlarged and photomicrographed from below to show characteristic markings. About 30 diameters.

5. Culture 5 days old of a pearl gray to puritan gray strain supposedly mutant. Note light-colored concentric ring similar to that of the primuline yellow bacterium, and the elliptical to fusiform deep colonies. The bacterial mass ran down the surface when the plate was vertically placed for photomicrographing. Characteristic "mottling" is also visible. About natural size.

PLATE 5

Longitudinal section of Smooth Cayenne fruit with six positive needle-puncture inoculations with *Erwinia ananas* in *a* and six negative needle punctures (check) in *b*. Note characteristic discolorations in *a* and healthiness in *b*. About $\frac{2}{3}$ natural size.

PLATE 6

Longitudinal section of Smooth Cayenne fruit with six positive needle-puncture inoculations with *Penicillium* sp. in *a* and six negative needle punctures (check) in *b*. The discolorations in *a* are not characteristic of the bacterial disease; the cavities are filled with mycelial threads of this organism, which is not the case with typically diseased fruits. About $\frac{2}{3}$ natural size.

PLATE 7

FIG. 1. Cross section of four eye bowls showing mechanical cracks (indicated by the arrows) through which the pathogen and other secondary organisms may enter the fruit. Only one shows such cracks although all are diseased, as shown in fig. 2. The infection in this case must have passed through either the floral parts or ruptures at some point along the fissurelike slits connecting the eye cavity with the placental region.

2. Longitudinal section of four eyes.

3. Four fruitlets showing mixed infection with bacteria and molds. The course of penetration is traceable through the fissurelike slits and mechanical cracks. About natural size.

4. Two fruitlets showing early and old infections, the former passing through the rupture along the fissurelike slit (shown by the arrow), and the latter apparently through the floral parts. About twice natural size.

5. Infected fruitlets showing the characteristic nonspreading behavior of the rot, with fuscous black coloration. About 1.5 natural size.

PLATE 8

Four Smooth Cayenne fruits at the blooming stages most critical for infection.

FIG. 1. With five or six flowers at the base just beginning to open (about 4 weeks old).

2. With all the flowers of the basal half of the fruit opened (about 5 weeks old).

3. With flowers at the base drying and those at the middle just opening (about 6 weeks old).

4. With all the flowers dried except a few at the topmost part (about 7 weeks old). Blooming is generally over at the age of 2 months.

PLATE 9

FIG. 1. Longitudinal section of an infected fruitlet showing course of bacterial penetration as indicated by the arrows. At *1* is the base of the style from which two lines of infection, as at *2* and *3*, originate; at *4* is one of the three fissurelike slits leading into the placental regions along which is shown a rupture at *5*. Through this rupture infection may also take place. × 43.

2. Highly magnified section of *3* showing penetration of bacteria from cell to cell. × 1400.

PLATE 10

FIG. 1. Diagramatic illustration of a pineapple flower in cross section. At *a* is represented the whorl of bracts covering the eye cavity *b;* at *c* one of the three anthers; at *d* one of the three stamens; at *e* one of the three double petals; at *f* the triple style; at *g* the triple stigma; and at *h* one of the three fissurelike slits that lead into the placental cavity.

2. Photomicrograph of a cross section of the eye cavity, showing the seemingly impenetrable thickness of lignified external covering which protects the fruitlet from external factors. × 80.

PLATE 11

FIG. 1. Photomicrograph of a cross section of a fruitlet just below the eye cavity, showing the three eye slits leading down to the placental cavity. Note thickness of lignified external covering. × 43.

2. Same as fig. 1 but just below it and at the midsection, showing line of connection (*1–2–3*) between the triple style and the ovaries. × 80.

PLATE 12

FIG. 1. Cross section of an eye slit below the midsection, showing rupture at one end. Note discoloration due to infection. × 142.

2. As in fig. 1 but without visible rupture. × 142.

PLATE 13

FIG. 1. As in Plate 12, fig. 2 (*1–2–3*), highly magnified, showing bacterial masses in clumps, especially along the cell walls, × 1100.

236411——3

FIG. 2. As in fig. 1 but with ruptured cells forming a cavity *x*. Note short bacterial filaments. × 1100.

PLATE 14

FIG. 1. Thin placental covering of diseased fruitlet, showing presence of bacterial masses in clumps in all the cells. × 1100.

2. Photomicrograph of a longitudinal section of a discolored vascular bundle at the core, showing masses of the bacteria in one of the pitted vessels at the center of the picture. All other tubes in top and bottom were apparently free. × 1100.

PLATE 15

FIG. 1. Sugar cane (Luzon Purple) inoculated by needle puncture with *Erwinia ananas*. Note red streaks and radial discoloration. The red streaks extending to the two adjacent internodes are not visible in the photograph.

2. Guru shows practically the same reaction as Luzon Purple.

3. Negros Purple shows practically the same reaction as Guru and Luzon Purple. Figs. 1, 2, and 3 are about natural size.

4. Photomicrograph of a longitudinal section of a discolored vascular bundle in the adjacent internodes, showing masses of the bacteria in one of the bundle-sheath cells at the center of the picture. All cells on left and right were apparently not infected. × 1100.

PLATE 16

Portion of a pineapple field at Calauan, Laguna Province, Luzon.

PLATE 17

FIG. 1. *Erwinia ananas* sp. nov., smear preparation from 20-hour-old culture, stained with gentian violet. × 1700.

2. Same as fig. 1, but showing bipolar staining with Verhoeff's carbol fuchsin. × 2000.

3. Same as fig. 1, but stained by Welch's (6) method to show presence of capsule. × 2000.

4. Same as fig. 1, but 4 days old. Stained with Verhoeff's carbol fuchsin, showing unstained areas usually on two poles. Most of the bacteria are in pairs. × 2000.

5. Same as fig. 1, but stained by van Ermengem's (6) method to show flagella. × 1550.

6. Same as fig. 5, but more highly magnified. × 4000. Note peritrichous flagella shown in both preparations.

7. Same as fig. 1, but stained by Plimmer's (10) method to show flagella. This confirms the evidence of figs. 5 and 6 that the pathogen is a peritricheate bacterium. × 3400.

PLATE 18

Fig. 1. *Erwinia ananas* sp. nov., smear preparation from 3-day-old slant culture, showing zoöglœalike formation at some point along the streak. Stained by Welch's (6) method. Note covering of mucuslike matrix on most of the bacterial cells. × 2000.

FIG. 2. *Erwinia ananas* sp. nov. smear preparation from 3-day-old slant culture, showing patches of mineral gray to tea green color at some point of the streak instead of zoöglœalike matrix. Note variation in size and form of the rods, suggestive of degeneration. × 2000.

PLATE 19

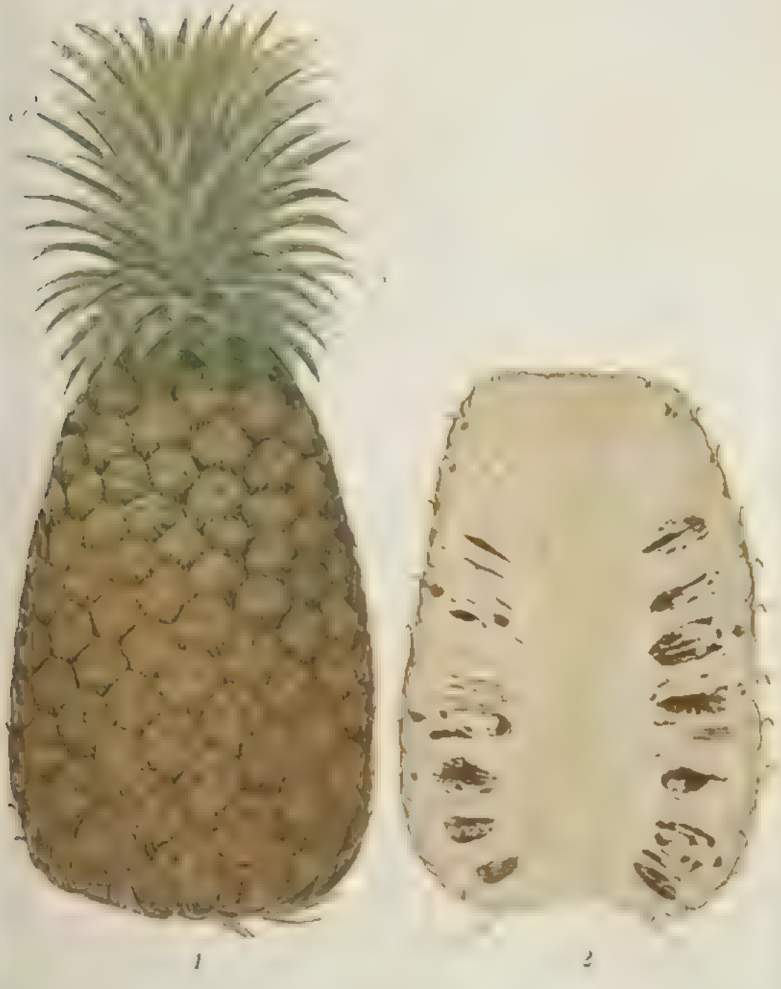
FIG. 1. *Erwinia ananas* sp nov., smear preparation from 4-day-old slant culture. Note elongated rods and irregular staining with Verhoeff's carbol fuchsin. × 2000.

2. *Erwinia ananas* sp. nov., smear preparation from 3-day-old slant culture. Note long filaments with irregular staining with Verhoeff's carbol fuchsin, and the more or less deformed rods. × 2000.

TEXT FIGURE

FIG. 1. Temperature studies. Graphs representing temperature relations (from 6 a. m. to 6 p. m.) between the pineapple, the soil, and the enviroment in correlation with the prevalence of the disease. Upper graph from data collected in Calauan, Laguna Province; lower graph, from Silang, Cavite Province.

PLATE 1.



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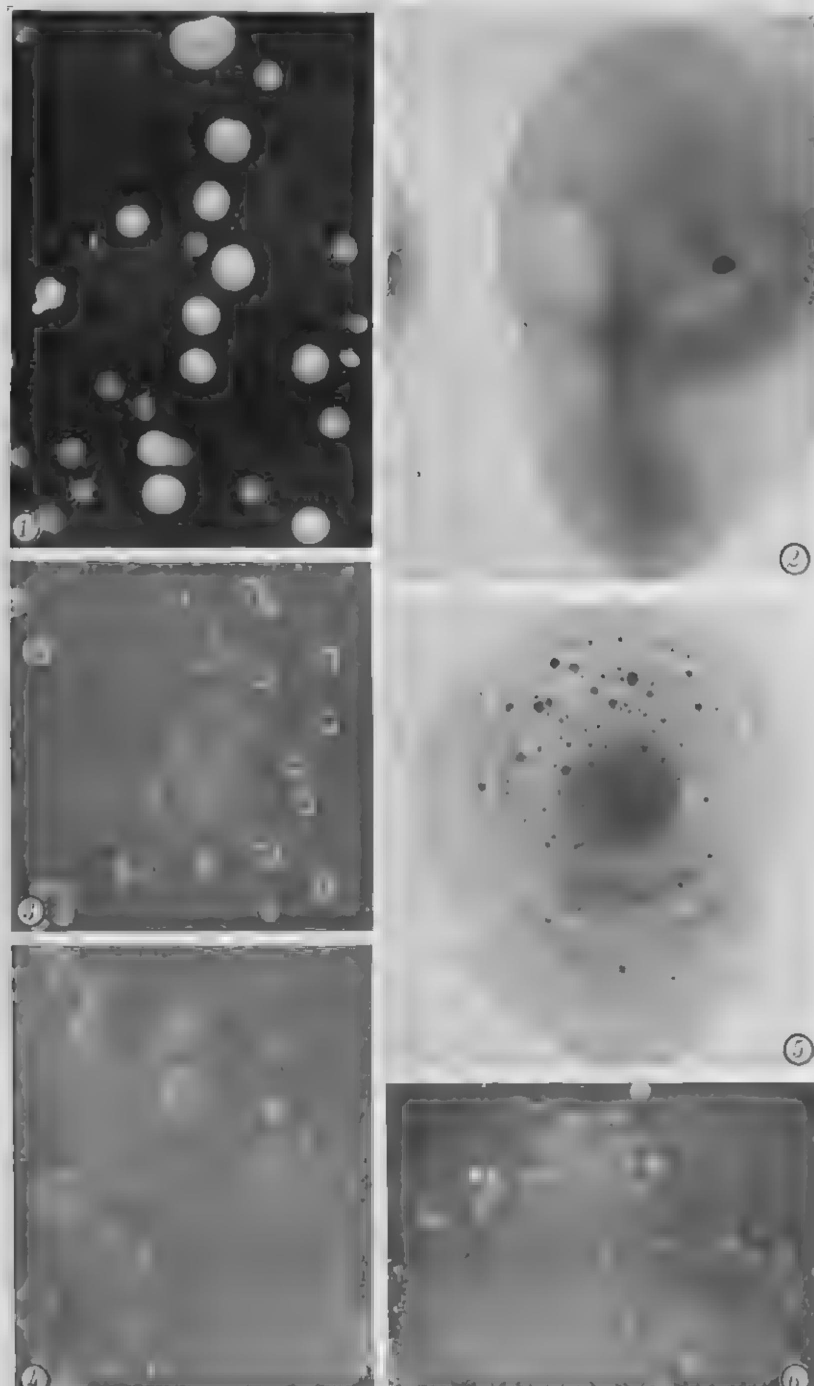

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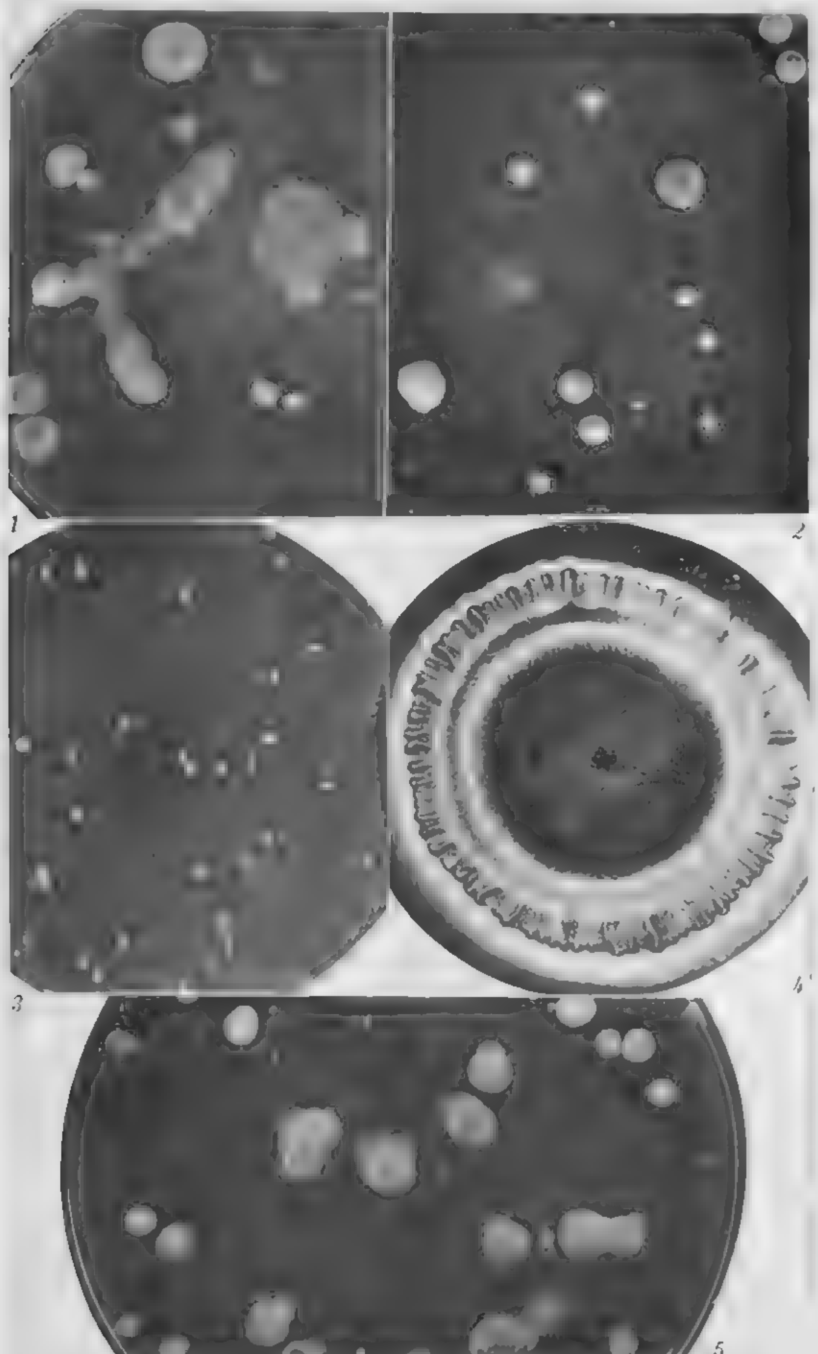

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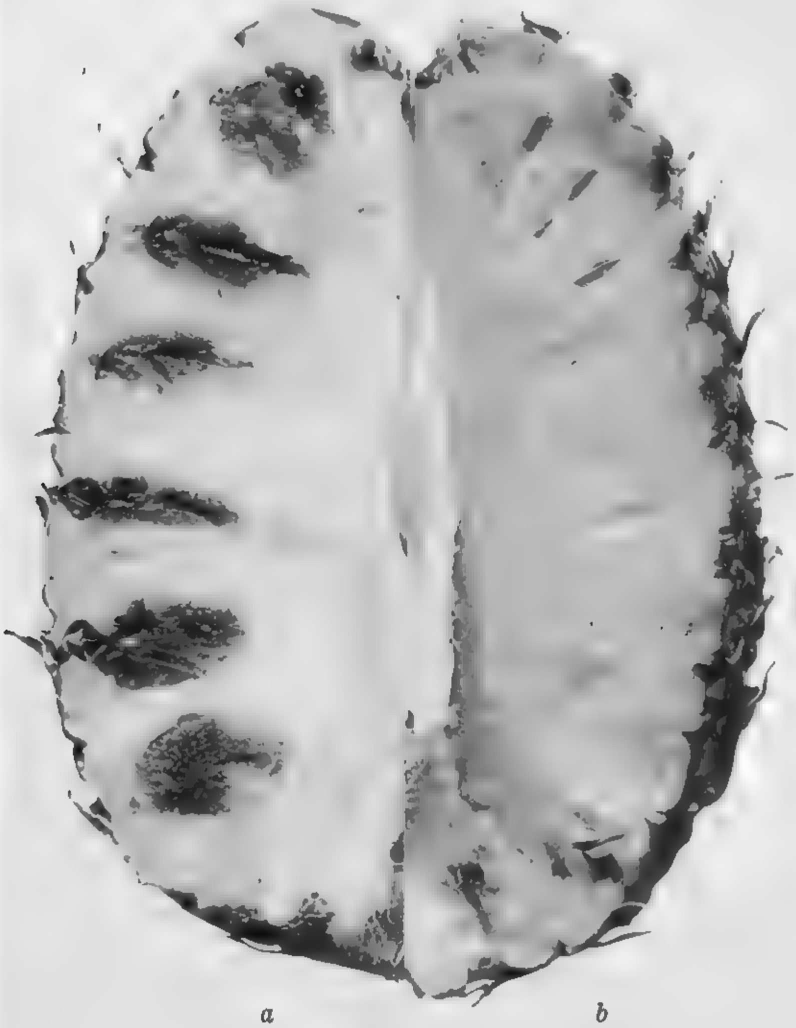

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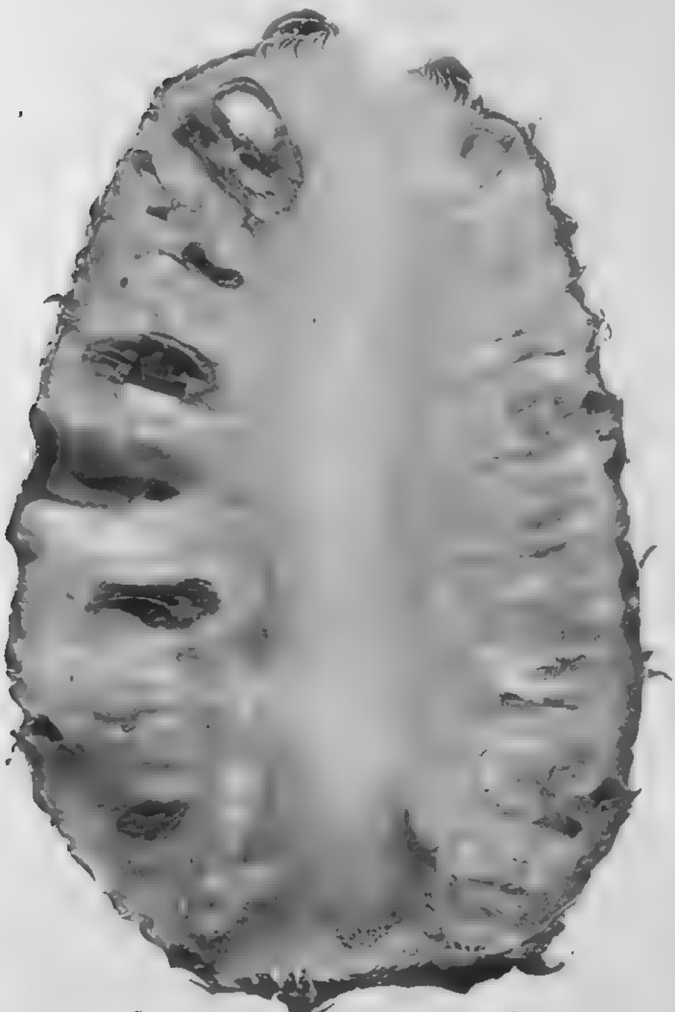

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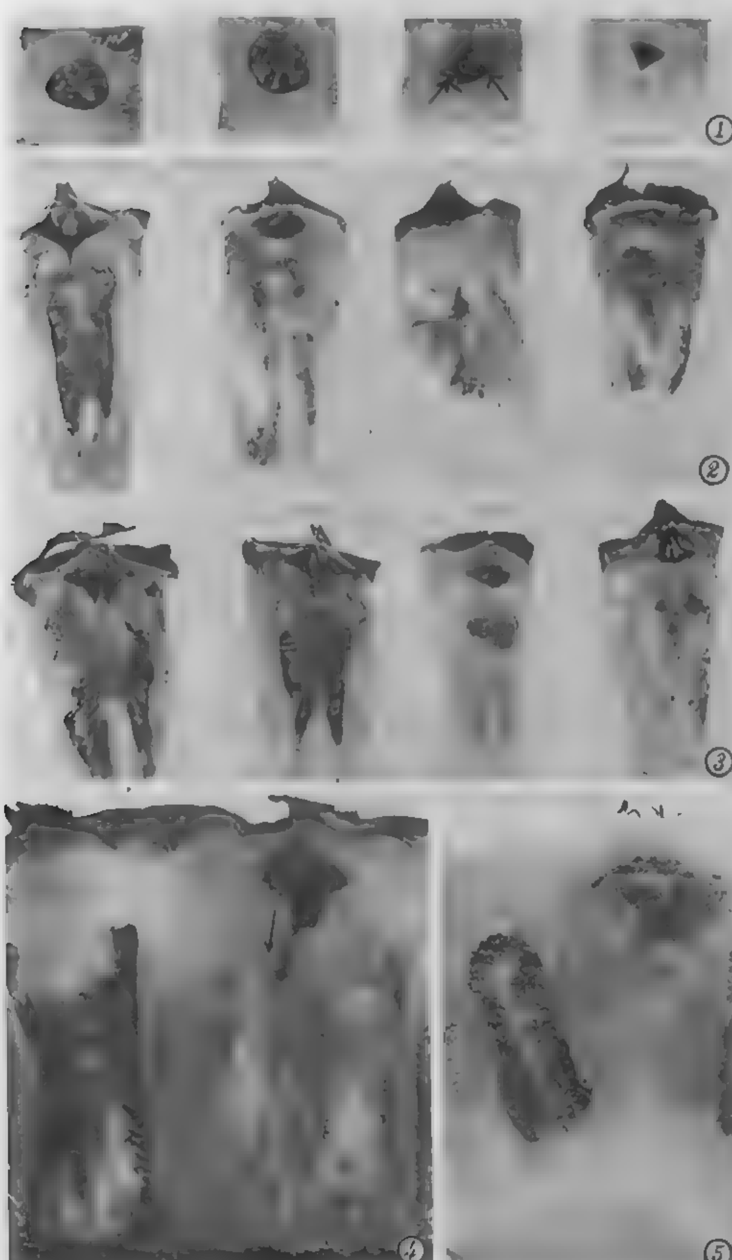

PLATE 7.

1 2

3 4

PLATE 8.

1

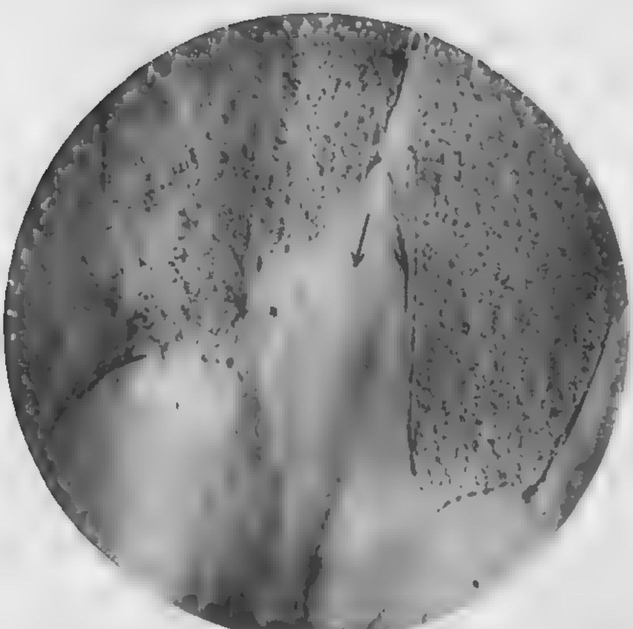

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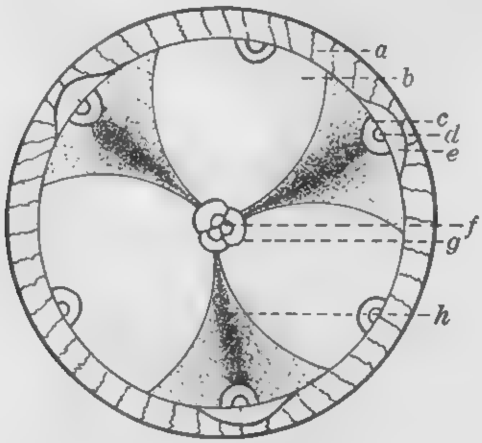
PLATE 9.



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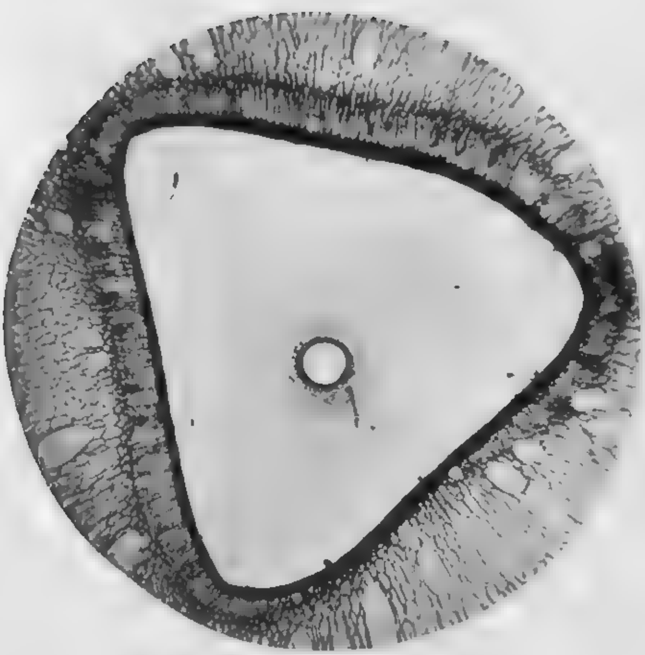

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PLATE 10.

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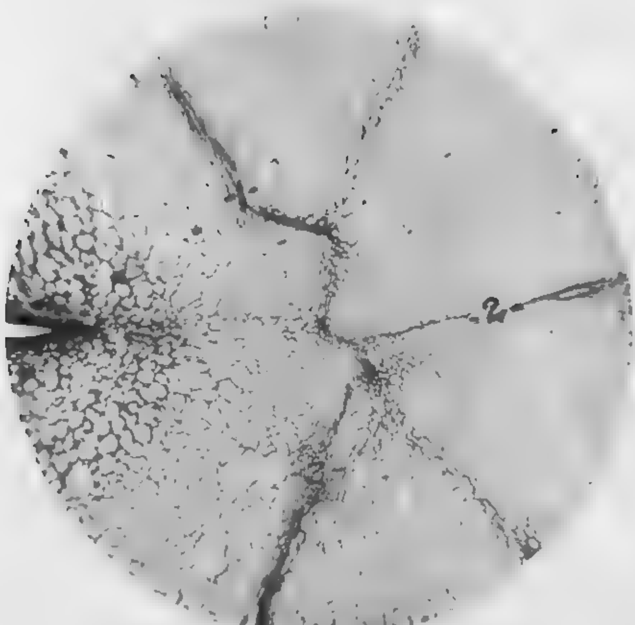

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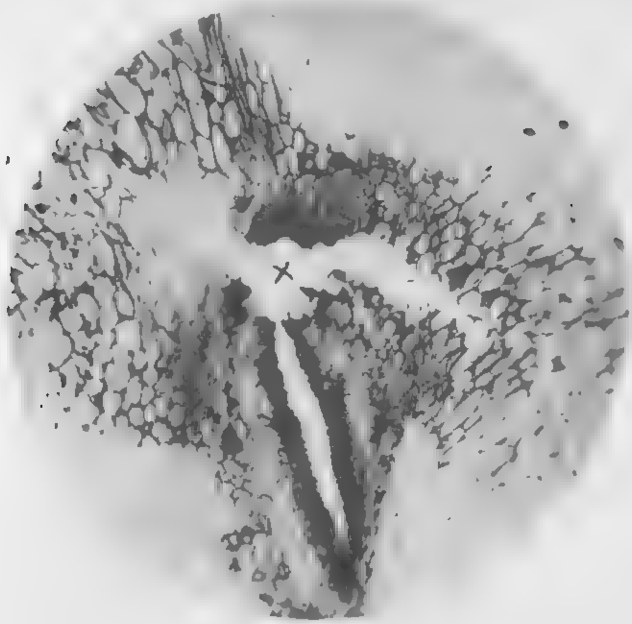
PLATE 11.



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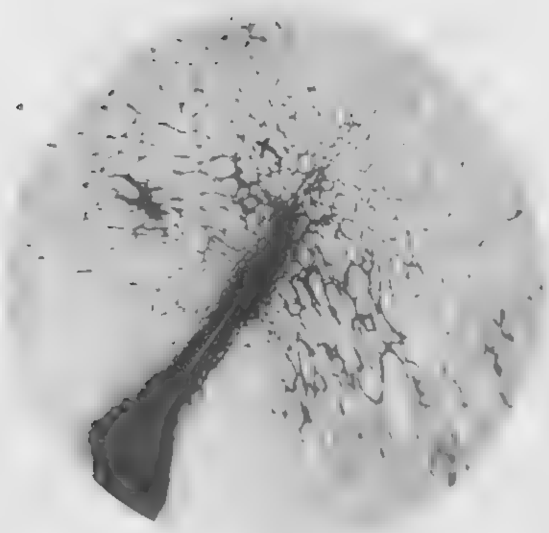

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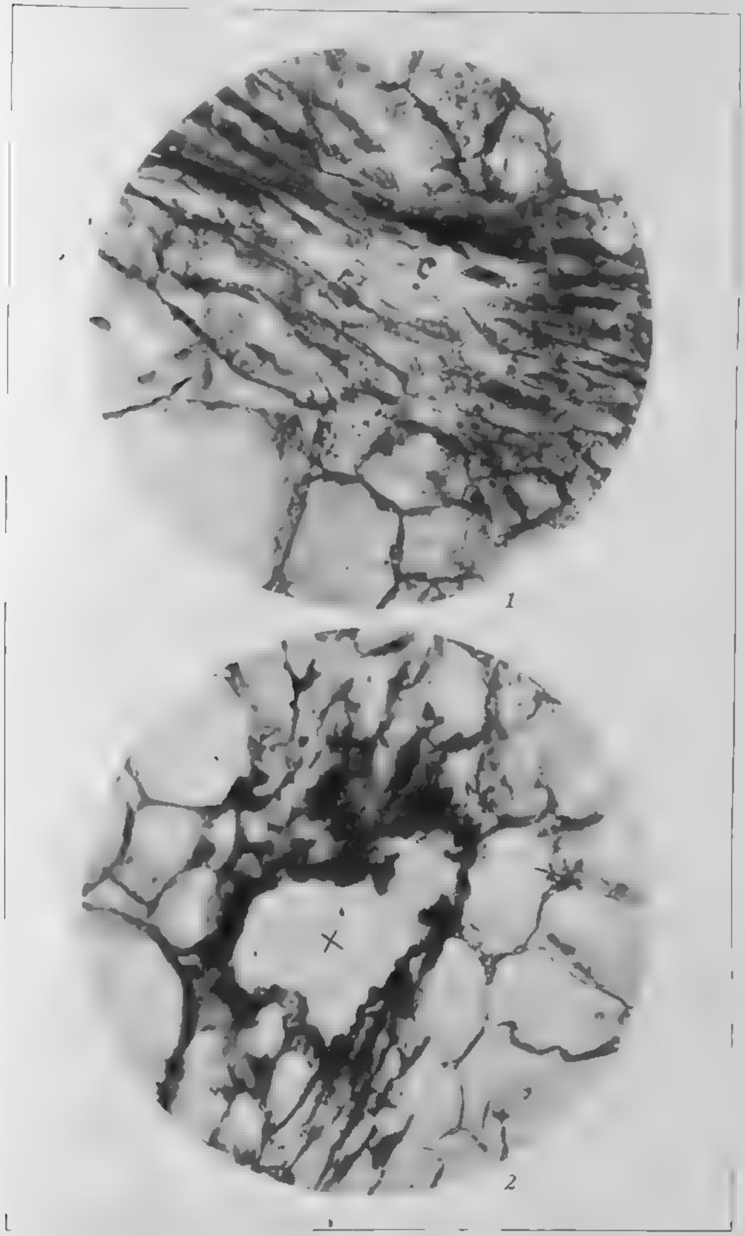
PLATE 12.



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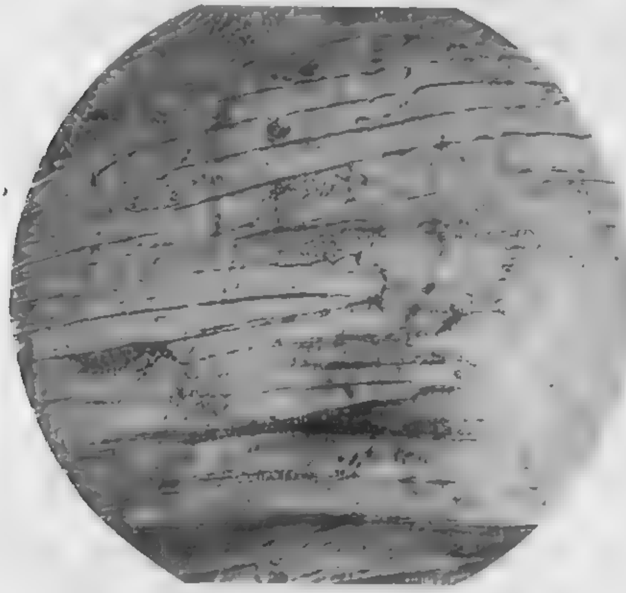

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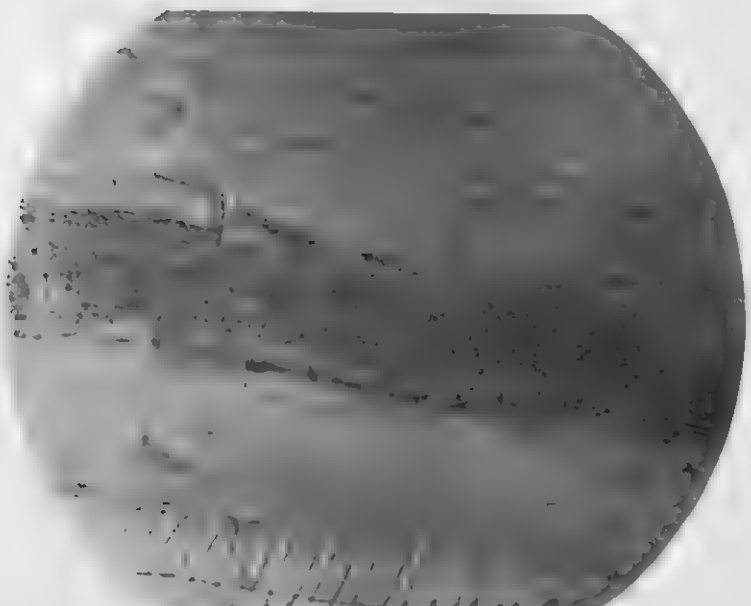

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PLATE 14.

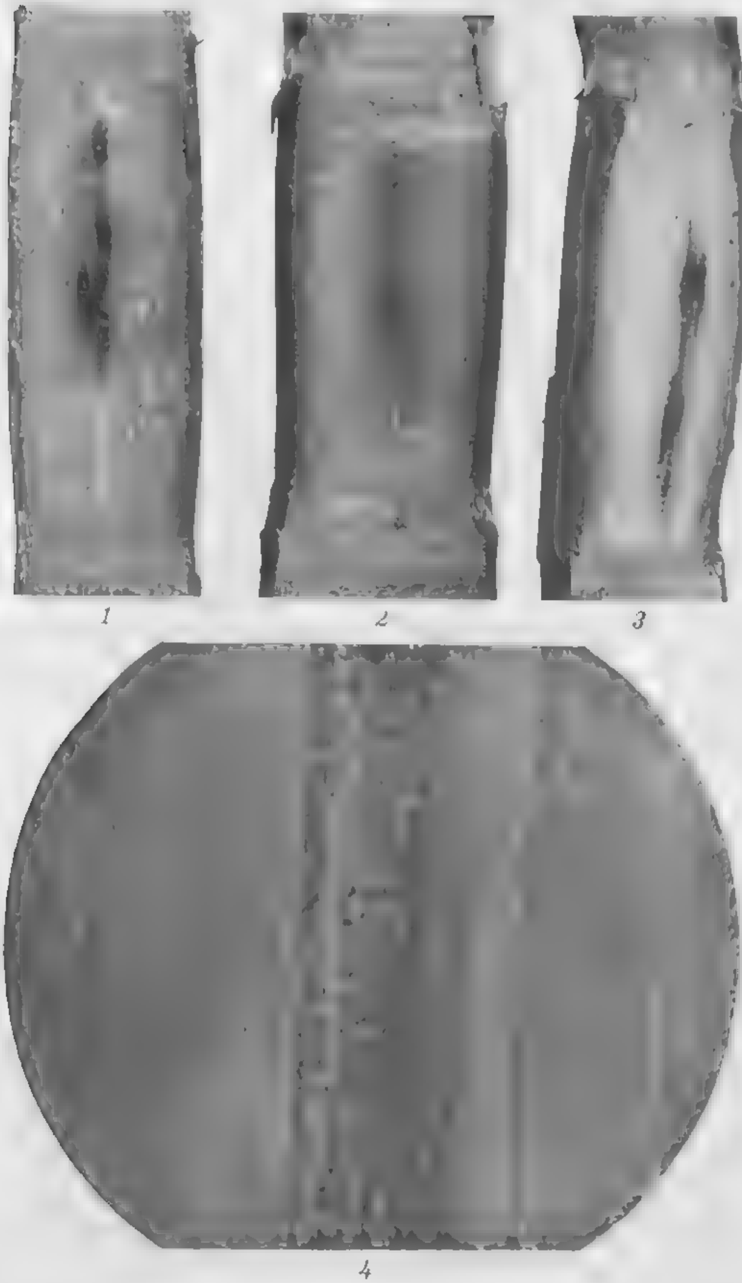


PLATE 15.

PLATE 16.

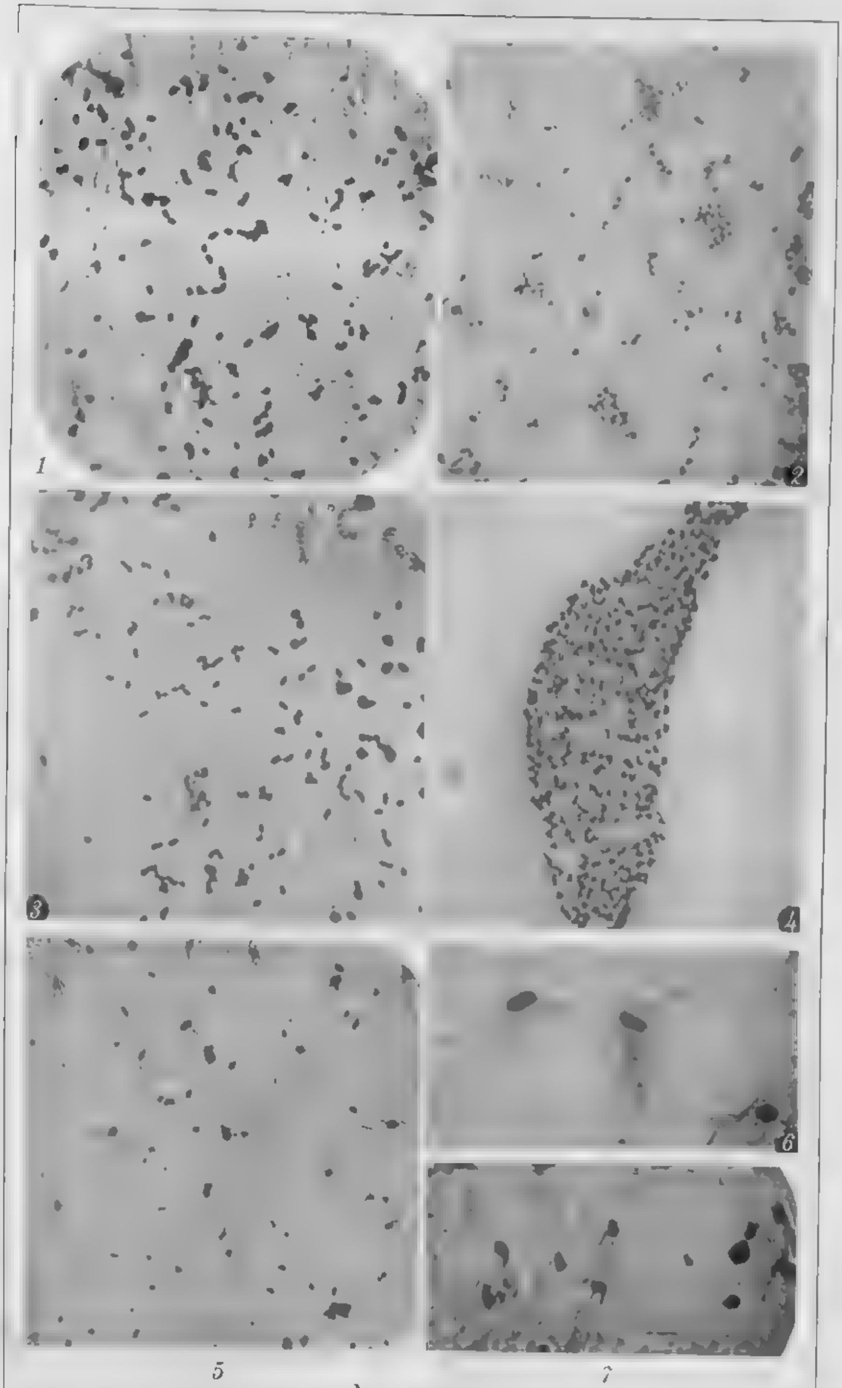
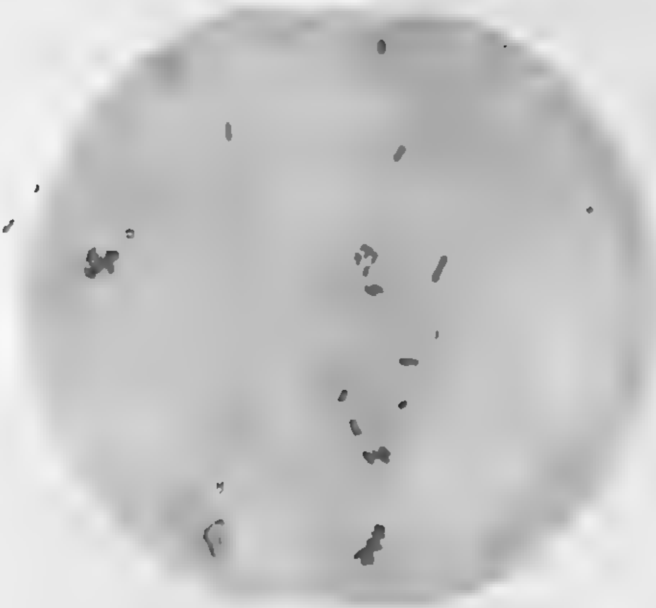


PLATE 17.



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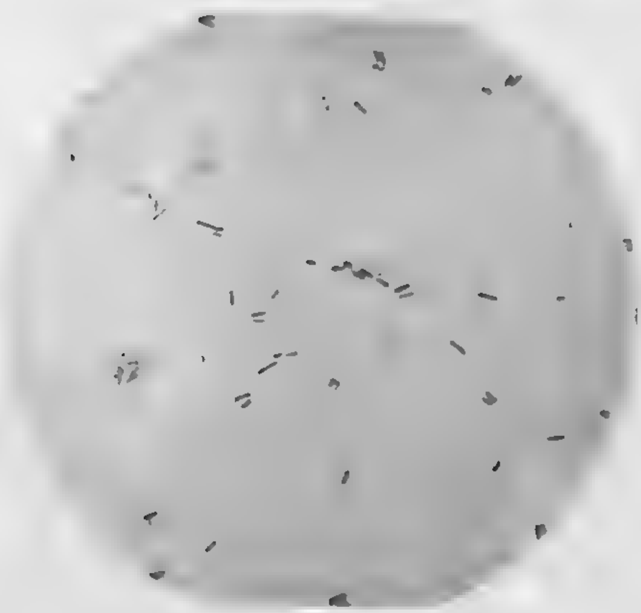

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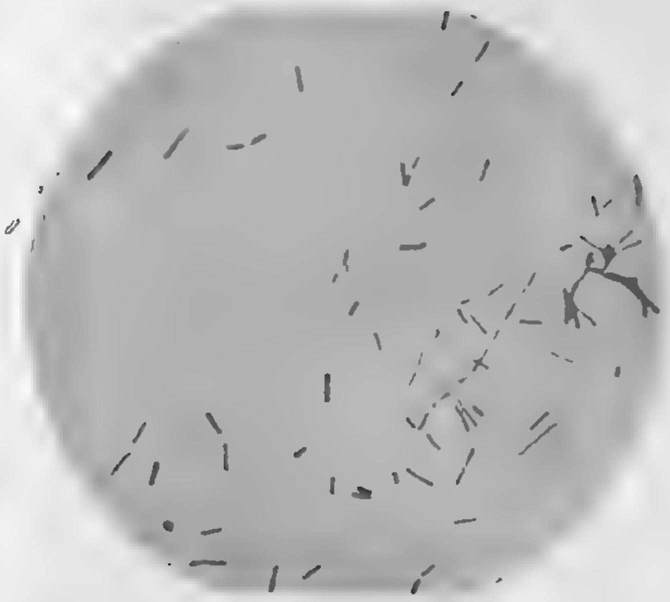
PLATE 28.



1

2

PLATE 19.

REVISION OF THE PHILIPPINE SPECIES OF THE CLYTINI (COLEOPTERA, LONGICORNIA)

By CHR. AURIVILLIUS

Of the Riksmuseum, Stockholm, Sweden

ONE PLATE

The main part of the material used for the compilation of this revision was received from Mr. C. F. Baker, Los Baños, Luzon. Other specimens were collected by G. Boettcher and are now deposited in the Riksmuseum, Stockholm.

Eight genera are represented in the Philippine fauna. They may be easily separated by the characters given in the following synopsis (essentially after Gahan [1]).

Key to the Philippine genera of Clytini.

a^1. Antennæ widely separated at base; the head between them not at all raised (front and vertex without limit passing in each other) or only slightly raised at the sides.

  b^1. Head carinate in front. Prothorax not or only slightly asperate. *Xylotrechus* Chevrolat.

  b^2. Head not at all carinate in front. Forehead broad. Prothorax strongly asperate above the middle.................... *Perissus* Chevrolat.

a^2. Antennæ not widely separated at the base; head between them with two subapproximate divergent elevations.

  b^1. First joint of hind tarsi much longer than second and third united.

    c^1. Antennæ not spined.

      d^1. Antennæ with the third joint not or hardly longer than first. *Chlorophorus* Chevrolat.

      d^2. Antennæ with the third joint distinctly longer than first. Elytra long and narrow. Episterna of metathorax with straight inner margin .... *Rhaphuma* Pascoe.

    c^2. Antennæ spined at least at apex of third joint.

      d^1. Third joint only spined at apex; this joint not longer than fourth. *Psilomerus* Chevrolat.

      d^2. Third and fourth joints spined at apex; third joint longer than fourth. Fifth and sixth joints also sometimes with a short spine... *Demonax* Thompson.

  b^2. First joint of hind tarsi very little or not longer than the following joints united. Elytra with the shoulders not carinate. Third and fourth joints of the antennæ with short apical spine. *Oligoenoplus* Chevrolat.

[1] Fauna Brit. India Coleoptera 1 (1906) 240.

Genus XYLOTRECHUS Chevrolat

All the species known from the Philippine Islands belong to the division with noncarinate femora. The subgenus *Xylotrechus* (type *X. pulcher* Aurivillius) has the middle femora only and the subgenus *Dendrotrichus* (type *X. decoratus* Pascoe) both the middle and the hind femora carinate.

Key to the species of Xylotrechus Chevrolat.

a^1. Eyes large, extended on the front. The face contracted in the middle between the eyes or at least very narrow. The front in the middle with two very distinct carinæ, which converge downward and unite so as to form a single median carina on the lower part of the face. Markings yellowish or grayish. Elytra each with five markings. Prothorax above with black markings.

b^1. Elytra without humeral stripe, but behind the shoulders with a transverse, externally angulate, free spot or short fascia. Prothorax above with two large black spots and a median black stripe, which often are united to a crosslike marking.......... *X. phidias* Newman.

b^2. Elytra with a humeral stripe, directed obliquely against the suture but not reaching the second transverse band. *X. antennarius* Heller.

a^2. Eyes smaller. Front broader with one to three very fine lines.

b^1. Front broad and flat with three very fine parallel lines.

c^1. Elytra with large cinereous humeral spot....*X. humeralis* sp. nov.

c^2. Elytra without humeral spot................ *X. mindanaonis* sp. nov.

b^2. Front with a median furrow including a single obsolete carina. *X. luzonicus* sp. nov.

XYLOTRECHUS PHIDIAS Newman.

Clytus phidias NEWMAN, Entomologist 1 (1842) 246.
Xylotrechus phidias WATERHOUSE, Proc. Ent. Soc. London (1874) 27.
Xylotrechus phidias AURIVILLIUS, Ent. Tidskr. 14 (1898) 163.

PALAWAN. LUZON. MINDANAO.

XYLOTRECHUS ANTENNARIUS Heller.

Xylotrechus antennarius HELLER, Tijdschr. v. Ent. 69 (1926) 24, pl. 5, fig. 17.

MINDANAO.

I do not see how this species may be differentiated from *X. pedestris* Pascoe from Borneo.

XYLOTRECHUS HUMERALIS sp. nov. Plate 1, fig. 1.

Femora haud carinata. Elytra apice omnino rotundata inermia. Frons aequilata, lineis tribus tenuibus instructa. Tarsorum posticoram articulus basalis reliquis simul sumtis parum longior. Prothorax elytris haud vel vix angustior. Articuli 9–11 aut 8–11 antennarum pallidi, albicantes. Fusco-niger, cinereo-pubescens elytris signaturis cinereo-tomentosis ornatis.

Vertex discrete punctatus. Prothorax elongatus, latitudine basali multo longior, ellipsoideus vel subcylindricus, supra longitudinaliter convexus, lateribus leviter arcuatis, punctatus punctis pube fere obtectis, unicolor cinereus vel fascia transversa fusca obsoleta instructus. Scutellum albidum. Elytra subnuda, nigra, plaga magna diffusa humerali, ante medium fascia lineari oblique a margine versus suturam et ad suturam usque ad scutellum adscendente, plaga communi pone medium antice ad suturam basin versus plus minusve producta apiceque cinereotomentosis ornata. Corpus infra cinereum, episternis meso- et metathoracis nee non later abdominis albis aut albidis. Long. corporis 5–10 mm.

SAMAR. NEGROS, Cuernos Mountains (*C. F. Baker*). Collectio Baker, Riksmuseum, Stockholm.

Nearly allied to *X. mindanaonis* sp. nov., but differing by the great humeral spot on the elytra.

XYLOTRECHUS MINDANAONIS sp. nov.

Frons aequilata, plana, lineis tribus tenuibus elevatis instructa. Femora haud carinata. Niger, ex parte cinereo-pubescens. Caput et prothorax dense cinereo-pubescentia; pronotum fascia lata transversa denudata nigricante ornatum et interdum fere ad basin nigricans, logitudinaliter convexum, elytris vix angustius. Scutellum album. Elytra subnitida, fere nuda, nigra, minute punctulata, fasciis maculisque cinereo-tomentosis ornata; fascia angusta basali interdum utrinque dilatata, ad humeros fere extensa, fascia obliqua lineari ante medium juxta suturam usque ad scutellum extensa, plaga communi trigona pone medium ad suturam antrorsum acuminata fasciaque transversa apicali. Antennae breves, medium elytrorum attingentes articulis tribus ultimis pallidis. Latera metasterni et segmenta duo basalia abdominis dense albo-hirsuta. Long. corporis 6–7 mm.

MINDANAO, Surigao, Kolambugan (*C. F. Baker*). Collectio Baker, Riksmuseum, Stockholm.

Nearly allied to *X affinis* Gahan, but differing in basal and apical markings of the elytra.

XYLOTRECHUS LUZONICUS sp. nov. Plate 1, fig. 2.

Femora haud carinata. Frons aequilata, latitudine altior, in medio sulcata et obsolete unicarinata. Nigricans, cinereo-pubescens, signaturis albido-tomentosis ornatus, praesertim in pedibus erecte pilosus. Antennae breves, articulo 8° humeras attigentes, ante medium fuscescentes, articulis 6–11 dense albidopubescentes; scapus articulo 3° brevior. Prothorax elongatus,

pone medium latior, sat nude punctulatus, cinerascente hirsutus maculis tribus rotundatis nigris denudatis, una basali, singula utrinque discali, in medio obsolete carinatus. Scutellum albido-hirsutum, late rotundatum. Elytra denudata, nigra, apice late rotundata, inermia, dense punctulata, ad basin parum diffuse cinereo-hirta, fasciis binis maculaque apicali cinereo-albidis ornata; fascia prima ante medium leviter curvata ad suturam basin versus producta, scutellum tamen haud attingente, fascia secunda paullo pone medium transvera lineari ad suturam longe producta, angulum subrectum formante. Latera pectoris abdominisque dense albido-hirsuta. Femora postica apicem abdominis parum superantia. Articulus basalis tarsorum posticorum compressus, reliquis simul sumtis parum vel vix longior. Long. corporis 10–12 mm.

LUZON, Mount Banahao. Riksmuseum, Stockholm.

Genus PERISSUS Chevrolat

The species of this genus are nearly allied to the species of *Xylotrechus,* but always easily known by the very broad forehead, entirely smooth without carinæ, the strongly asperate prothorax, and the spined outer apical angle of the elytra. The basal joint of the hind tarsi much longer than the other three taken together.

Only one somewhat variable species hitherto known from the Philippine Islands.

PERISSUS SCUTELLATUS Chevrolat.

Perissus scutellatus CHEVROLAT, Mém. Soc. Sc. Liége 18 (1863) 267 (sep. 15).

The elytra have nearly the same cinereous marking as in *Xylotrechus humeralis,* but the first fascia does not reach the scutellum. Prothorax usually with two black spots. Length, 7 to 13 millimeters.

Male.—Hind femora extending past the apex of the elytra. Antennæ longer, reaching past the second fascia of the elytra.

Female.—Hind femora hardly reaching past the elytra. Antennæ shorter, not reaching past the second fascia of the elytra.

PALAWAN. LUZON. SAMAR. NEGROS. SIBUYAN. MINDANAO.

Genus CHLOROPHORUS Chevrolat

(*Caloclytus* Gahan)

The type of this genus is the well-known *Clytus annularis* Fabricius. The species are easily recognized by the narrow head between the antennæ, the front being distinctly separated from

the vertex by an elevation between the antennæ. Antennæ unarmed. The middle femora are, in all the Philippine species, furnished with a fine carina along each side.

Key to the species of Chlorophorus Chevrolat.

a^1. Covered above with yellow or yellowish pubescence and varied with black or blackish markings. Elytra with four pale fasciæ, the first basal or at least represented by a humeral spot.
  b^1. Hind femora not carinate. Pronotum with a median posteriorly bifurcated black spot .... *C. annularis* Fabricius.
  b^2. Hind femora carinate. Pronotum with a median, posteriorly somewhat enlarged black line, reaching neither the base nor the apex. *C. palavanicus* Aurivillius.
a^2. Pubescence and markings above gray, whitish, or white.
  b^1. Pronotum not bordered with white at base. Larger species, 8 to 16 millimeters.
    c^1. Elytra without pale basal fascia or humeral gray spot. Subbasal pale fascia interrupted at the suture, broader than the linear median fascia .... *C. bakeri* Aurivillius.
    c^2. Elytra with a pale, gray or whitish, spot behind the shoulder.
      d^1. This spot entirely free.
        e^1. Hind femora, at least behind the middle, with a very fine lateral carina.
          f^1. Humeral spot of the elytra large and broad. Markings of the elytra gray.. *C. manillae* Aurivillius.
          f^2. Humeral spot of the elytra small linear. Markings of the elytra white or whitish.. *C. manillae* var. *lineifer* var. nov.
        e^2. Hind femora not carinate. Humeral spot of the elytra large, produced nearer to base than the sutural vitta. *C. aurivillii* Schwarzer.
      d^2. Humeral spot of the elytra posteriorly united to the subbasal fascia .... *C. basilanus* Heller.
  b^2. Pronotum bordered with white at base. Small species, 5 to 6 millimeters .... *C. nigerrimus* Chevrolat.

CHLOROPHORUS ANNULARIS Fabricius.

Callidium annulare FABRICIUS, Mant. Ins. 1 (1787) 156.
Caloclytus annularis GAHAN, Fauna Brit. Ind. Col. 1 (1906) 261.

LUZON. NEGROS. SIBUYAN. CEBU. BOHOL. MINDANAO. (Teste W. Schultze.)

CHLOROPHORUS PALAVANICUS Aurivillius.

Chlorophorus palavanicus AURIVILLIUS, Tijdschr. v. Ent. 65 (1922) 161.

Northern PALAWAN, Binaluan.

CHLOROPHORUS BAKERI Aurivillius.

Chlorophorus bakeri AURIVILLIUS, Arkiv f. Zoöl. 14 [18] (1922) 4, fig. 84.

LUZON, Mount Banahao.

CHLOROPHORUS MANILLAE Aurivillius.

Chlorophorus manillae AURIVILLUS, Arkiv f. Zoöl. 7 [18] (1911) 6.

LUZON.

CHLOROPHORUS MANILLAE var. **LINEIFER** var. nov.

A forma typica differt macula humerali elytrorum brevi, lineari et signaturis elytrorum albis.

MINDANAO, Bukidnon.

CHLOROPHORUS AURIVILLII Schwarzer.

Chlorophorus manillae, ab. *aurivillii* SCHWARZER, Ent. Mitt. 15 (Jan. 1, 1926) 7.

Chlorophorus bakeri subsp. *orbiculifer* HELLER, Tijdschr. v. Ent. 69 (April 15, 1926) 27.

MINDANAO.

CHLOROPHORUS BASILANUS Heller.

Chlorophorus bakeri subsp. *basilanus* HELLER, Tijdschr. v. Ent. 69 (1926) 26.

BASILAN.

CHLOROPHORUS NIGERRIMUS Chevrolat.

Anthobascus nigerrimus CHEVROLAT, Mém. Soc. Sc. Liége 18 (1863) 302 (sep. 50).

MINDANAO.

Genus RHAPHUMA Pascoe

Long and narrow, often vividly colored species, which differ from the species of *Chlorophorus* only by the long third joint of the antennæ.

Key to the species of Rhaphuma Pascoe.

a^1. Pronotum and elytra testaceous red or yellowish. Each elytron only with one black spot (near the white apex). Body beneath banded with white pubescence. Lateral margins of the elytra distinctly sinuate in the middle. Femora not carinate.

- b^1. Pronotum without white lines; only with a white dot on each side at base. Elytra without median white spot. Hind legs blackish. *R. quadricolor* Laporte and Gory.
- b^2. Pronotum with two short white lines. Elytra each with a small white median spot. Legs testaceous................ *R. fallax* Chevrolat.

a^2. Pronotum and elytra black, with grayish or yellowish green markings.

- b^1. Elytra with gray or whitish gray markings, which are short and partly transverse and free. Middle femora carinate. *R. campanulifera* Aurivillius.
- b^2. Elytra with greenish markings, which are long and more rectilinear. *R. semiclathrata* Chevrolat.

RHAPHUMA QUADRICOLOR Laporte and Gory.

Clytus quadricolor LAPORTE and GORY, Monogr. des Clytus (1835) 104, pl. 19, fig. 123.

Rhaphuma quadricolor CHEVROLAT, Mém. Soc. Sc. Liége 18 (1863) 276 (sep. 24).

LUZON.

RHAPHUMA FALLAX Chevrolat.[a]

Rhaphuma fallax CHEVROLAT, Mém. Soc. Sc. Liége 18 (1863) 276 (sep. 24).

LUZON. PALAWAN (teste W. Schultze).

RHAPHUMA CAMPANULIFERA Aurivillius.

Rhaphuma campanulifera AURIVILLIUS, Arkiv f. Zool. 14[18] (1922) 8, fig. 90.

LUZON, Mount Banahao.

RHAPHUMA SEMICLATHRATA Chevrolat.[a]

Arcyphorus semiclathratus CHEVROLAT, Mém. Soc. Sc. Liége 18 (1863) 289 (sep. 37).

"Philippine Islands."

Genus PSILOMERUS Chevrolat

Slender and rather small species with the prothorax nearly cylindrical or narrowed in front, much longer than broad. The spine of the third antennal joint long and cylindrical with its apex blunt.

Only one species is known from the Philippine Islands.

PSILOMERUS BRACHIALIS Chevrolat.

Psilomerus brachialis CHEVROLAT, Mém. Soc. Sc. Liége 18 (1863) 258 (sep. 6).

MINDANAO. NEGROS.

Black with the hind border of the pronotum and three spots on each elytron white. The first spot small longitudinal before the middle, the second a transverse straight fascia near the middle, the third oblique and nearly apical.

Genus DEMONAX Thomson

This genus is very rich in species and is in great need of a thorough monographic revision. About thirty species are already known from the Philippine Islands, nearly all probably endemic.

[a] Unknown to me from the Philippines.

Key to the Philippine species of Demonax Thomson.

a[1]. Body at least in part yellowish or yellowish red. Elytra clothed with yellowish pubescence and marked with black bands or lateral spots. Spines of the antennæ short and acute.

b[1]. Elytra above from base to beyond middle unicolorous, clothed with a yellow pubescence; each behind the middle with two elongate lateral black spots .... *D. longicollis* Heller.

b[2]. Elytra also before middle with black markings.

c[1]. The first, second, and third yellow bands of the elytra united at suture, but separated at margin by large black spots.

d[1]. First lateral black spot of the elytra oblique, curved basad.
D. nigroscutellaris Heller.

d[2]. First lateral black spot of the elytra transverse.
D. diversofasciatus Heller.

c[2]. The first, second, and third yellow bands of the elytra entirely separated from each other by black transverse bands.

d[1]. Basal yellow band of the elytra represented by two separate spots .... *D. protogenes* Newman.

d[2]. Basal yellow band of the elytra continuous, including the scutellum .... *D. strangaliomimus* Heller.

a[2]. Body black or fuscous with grayish or somewhat yellowish pubescence. Elytra with gray or white (rarely yellowish or greenish) markings.

b[1]. Third and fourth joints of the antennæ at apex with an acute spine.

c[1]. Elytra only with two or three pale bands; the basal band wanting.[a] Small species, 5 to 7 millimeters long.

d[1]. Elytra with a common sutural white spot or short streak behind the scutellum. Pronotum with a white or whitish basal ring.

e[1]. Spines of the antennæ rather long. Subbasal band of the elytra represented by a rounded, somewhat transverse spot. Basal band sometimes slightly indicated.
D. lineola Chevrolat.

e[2]. Spines of the antennæ very short. Subbasal white band of elytra oblique, angulated, and nearly continuous at suture.
D. triguttatus Schwarzer.

d[2]. Elytra without common white sutural spot behind the scutellum. Spines of the antennæ very short.

e[1]. Subbasal white band of the elytra continuous or nearly so, forming an angle at the suture or a ∧-shaped figure.
D. collaris Chevrolat.
D. similis Schwarzer.

e[2]. Subbasal band represented on each of the elytra by a white spot.

f[1]. Basal margin of the pronotum not or slightly clothed with white pubescence. Subbasal spot of the elytra rounded.
D. biguttatus Aurivillius.

f[2]. Basal margin of the pronotum densely clothed with white tomentum.

[a] Rarely slightly indicated.

g^1. Subbasal spot of the elytra rounded.
D. aurivillii Schwarzer.

g^2. Subbasal spot of the elytra elongate.

h^1. Placed obliquely .... *D. ater* Aurivillius.

h^2. Placed longitudinally........................... *D. frater* Aurivillius.

c^2. Elytra with four grayish or greenish bands, of which the first is basal.

d^1. First and second bands of the elytra united at the suture behind the scutellum, but broadly separated on the outer side, usually forming with each other an X-shaped sign.

e^1. Elytra with the second and third bands narrow, united at the suture; the second recurved at outer end. Antennæ with very short spines.................................... *D. recurvus* Aurivillius.

e^2. Second and third bands of the elytra not united at the suture; the third broad, more or less triangular.

f^1. Bands of the elytra distinctly greenish. Transverse part of second band interrupted near the suture, forming a free discal spot.. *D. virescens* sp. nov.

f^2. Bands of the elytra gray. Antennæ with the spines of the third and fourth joints long.

g^1. Antennæ with the fifth joint unarmed. Prothorax more elongate .... *D. dubius* sp. nov.

g^2. Fifth joint of the antennæ with a very short spine at apex. Prothorax broad, subglobular.
D. triaculeatus Aurivillius.

d^2. First and second bands of the elytra united as well at the suture as at the outer (lateral) side, inclosing a black spot or marking.

e^1. The inclosed spot forms a straight, somewhat oblique, black stripe from the scutellum to the middle of the disk. Antennæ with rather long spines.

f^1. The inclosed black stripe ends bluntly posteriorly and is not recurved.. *D. angusticollis* sp. nov.

f^2. The inclosed black stripe is recurved at its posterior end and reaches the shoulder as a fine black line.
D. detortus Pascoe.

e^2. The inclosed black spot is broad, irregular, and sends a narrow branch to the shoulder. Antennæ with short spines.
D. robustus sp. nov.
? D. incanus Newman.

b^2. Third and fourth joints of the antennæ with a long, nearly filiform spine which is blunt at the apex.

c^1. Elytra only with three pale bands, the basal band wanting or only slightly indicated. Small species, 6 to 8 millimeters.

d^1. Subbasal band of the elytra produced at the suture to the scutellum .... *D. trifasciatus* sp. nov.

d^2. Subbasal band of the elytra not reaching the scutellum.
D. coriaceocollis Aurivillius.

c^2. Elytra with four grayish brands, the first basal. Larger species, 9 to 14 millimeters.

d^1. Basal and subbasal bands of the elytra entirely separated by a broad and straight black fascia........ *D. parallelus* Aurivillius.

d^2. Basal and subbasal bands of the elytra united along the suture.

e^1. Broadly separated on the outer side, forming with each other an X-shaped sign.

f^1. Basal band of elytra nearly straight on the posterior side. *D. samarensis* sp. nov.

f^2. Basal band of elytra strongly recurved at shoulders.

g^1. Antennæ not paler in apical half.
D. seriatopunctatus Aurivillius.
D. confinis Aurivillius.

g^2. The last four or five joints of the antennæ pale, whitish .... *D. angulifascia* Aurivillius.

e^2. Also on the outer (lateral) side, completely including a triangular black spot, which is shortly projecting against the scutellum .... *D. includens* sp. nov.

DEMONAX LONGICOLLIS Heller.

Demonax longicollis HELLER, Deutsche Ent. Zeitschr. (1916) 302, pl. 3, fig. 11.

LUZON, Mount Maquiling.

DEMONAX NIGROSCUTELLARIS Heller.

Demonax nigrofasciatus nigroscutellaris var. n. ? HELLER, Deutsche Ent. Zeitschr. (1916) 304, pl. 3, fig. 10.

LUZON, Mount Maquiling. SIBUYAN.

This was described by Heller as a variety of *D. nigrofasciatus* Thomson from Batjan, but is probably a different species. The specimens before me differ in having the prothorax broadly blackish above and the episterna of mesothorax and metathorax clothed with a dense white tomentum. Antennal spines acute, moderately long. Femora noncarinate; posterior femora bispinous at apex.

DEMONAX DIVERSOFASCIATUS Heller.

Demonax diversofasciatus HELLER, Deutsche Ent. Zeitschr. (1916) 303, pl. 3, fig. 12.

MINDANAO, Butuan.

DEMONAX PROTOGENES Newman.

Clytus protogenes NEWMAN, Entomolog. 1 (1842) 246.
Clytus protogenes WHITE, Cat. Col. Brit. Mus. 8 (1855) 284.
Clytus protogenes WATERHOUSE, Aid Identif. Ins. 2 (1884) 149, fig. 5.

"Philippine Islands." LUZON. (?)

DEMONAX STRANGALIOMIMUS Heller.

Demonax strangaliomimus HELLER, Tijdschr. v. Ent. 69 (1926) 27, pl. 5, fig. 13.

MINDANAO, Davao.

DEMONAX LINEOLA Chevrolat.

Demonax lineola CHEVROLAT, Mém. Soc. Sc. Liége 18 (1863) 274 (sep. 22).

LUZON, Manila and Imugan.

DEMONAX TRIGUTTATUS Schwarzer.

Demonax triguttatus SCHWARZER.

MINDANAO, Kolambugan.

DEMONAX(?) PUDICUS Newman.

Clytus pudicus NEWMAN, Entomolog. 1 (1842) 246.

Philippine Islands. LUZON. (?)

Unknown to me. Probably allied to the following species.

DEMONAX COLLARIS Pascoe.

Demonax collaris PASCOE, Trans. Ent. Soc. London III 3 (1869) 636.

LUZON, Los Baños.

The species was described from Ceram. I have not seen any specimens from that island, but the description agrees very well with the specimens from Luzon before me.

DEMONAX SIMILIS Schwarzer.

Demonax similis SCHWARZER (not yet published).

MINDANAO, Momungan.

DEMONAX BIGUTTATUS Aurivillius.

Demonax biguttatus AURIVILLIUS, Arkiv f. Zool. 14^{18} (1922) 18, fig. 88.

LUZON, Mount Banahao.

DEMONAX AURIVILLII Schwarzer.

Demonax aurivillius SCHWARZER (not yet published).

MINDANAO, Momungan.

DEMONAX ATER Aurivillius.

Demonax ater AURIVILLIUS, Arkiv f. Zool. 14^{18} (1922) 18, fig. 89.

MINDANAO, Dapitan.

DEMONAX FRATER Aurivillius.

Demonax frater AURIVILLIUS, Arkiv f. Zool. 15^{25} (1923) 10, fig. 117.

MINDANAO, Bukidnon.

DEMONAX RECURVUS Aurivillius.

Demonax recurvus AURIVILLIUS, Arkiv f. Zool. 15[25] (1923) 11, fig. 118.

PALAWAN, Binaluan.

DEMONAX TRIACULEATUS Aurivillius.

Demonax triaculeatus AURIVILLIUS, Arkiv f. Zool. 14[15] (1922) 13, fig. 100.

MINDANAO, Dapitan. BASILAN.

DEMONAX DUBIUS sp. nov.

A doubtful and somewhat variable species, agreeing in the markings of the elytra very nearly with *D. angulifascia* Aurivillius from Luzon, but differing by the acute spines of the antennæ and the rather broader prothorax. From *D. triaculeatus* Aurivillius it differs by the narrower body and prothorax and much larger third fascia of the elytra, which has the same form as in *D. angulifascia*. The color of the last joint of the antennæ is somewhat variable; joints 8 and 9 are usually whitish and much paler than 10 and 11, but in one specimen from Samar all the four apical joints are whitish, and in another all dark. Length, 9 to 10 millimeters.

SIBUYAN. SAMAR. NEGROS (*C. F. Baker*). Collectio Baker, Riksmuseum, Stockholm.

DEMONAX VIRESCENS sp. nov. Plate 1, fig. 3.

♀. Nigro-fusca, infra cinereo-pubescens, supra subnuda signaturis elytrorum virescente-tomentosis. Frons subquadrata. Antennae corpore breviores, nigro-fuscae, spinis mediocribus; scapus subcylindricus, articulo 3° brevior. Prothorax ellipsoideus, latitudine longior, subnudus, nigricans, unicolor, minute reticulatus. Scutellum triangulum, niger. Elytra apicem versus sensim leviter angustata, apice truncata angulo externo breviter dentato, virescente signata; fascia basalis ad humeros retrorsum producta, fascia secunda postice transversa sed prope suturam interrupta, juxta suturam usque ad scutellum producta linearis; fascia tertia elongata, triangularis, apice lata; quarta lata apicalis. Episterna et latera abdominis albido-tomentosa. Long. corporis 8 mm.

LUZON, Imugan. Riksmuseum, Stockholm.

DEMONAX ANGUSTICOLLIS sp. nov. Plate 1, fig. 4.

Nigro fuscus, cinereo-pubescens; elytra fasciis 4 cinereis ornata, prima et secunda ad suturam et extus connexa striga

obliqua nigra includentibus. Antennæ maris corpore paullo longioribus, articulis 3° et 4° apice longe aculeatis, 8–11 albidis. Prothorax angustus, elongatus, latitudine longior, ad basin constrictus, punctatus aut leviter reticulatus, in medio punctis duobus nigris ornatus. Scutellum cinereum. Elytra angusta, linearia, apice truncata et extus spina brevi armate, margine laterali inter humerum et fasciam nigram mediam nigro. Corpus infra cinereo-pubescens, segmentis duobus apicalibus abdominis certo luce infuscatis. Femora haud carinata; postica apicem elytrorum longe superantia. Articulus basalis tarsorum posticorum elongatus, reliquis simul sumtis fere duplo longior. Long. corporis 6–8 mm.

NEGROS, Cuernos Mountains (*C. F. Baker*). Coll. Baker. Riksmuseum, Stockholm.

Nearly allied to *D. gregalis* Gahan, but differing by the longer and narrower prothorax.

DEMONAX ANGUSTICOLLIS var. SIBUYANUS var. nov.

A forma typica tantum differt lateribus elytrorum inter basin et fasciam nigram primam cinereis, antennisque apice vix pallidioribus.

SIBUYAN (*C. F. Baker*). Collectio Baker. Riksmuseum, Stockholm.

DEMONAX DETORTUS Pascoe.

Demonax detortus PASCOE, Trans. Ent. Soc. Lond. III 3 (1869) 624.

LUZON. SIBUYAN. SAMAR. NEGROS. MINDANAO. BASILAN.

Specimens from the Philippine Islands are as a rule larger than specimens from Borneo, but seem otherwise not to differ, either in markings or in structural characters.

DEMONAX (?) INCANUS Newman.

Clytus incanus NEWMAN, Entomolog. 1 (1842) 246.

LUZON. (?)

I have not seen Newman's type specimen, but think his species must be nearly allied to the following form.

DEMONAX ROBUSTUS sp. nov. Plate 1, fig. 5.

Niger, supra flavido-tomentosus, infra cinerascente-tomentosus, episternis albido-hirtis. Frons lata, subquadrata. Genae lobis inferioribus aculorum vix breviores. Antennæ corpore breviores, fasciam tertiam elytrorum vix superantes, fuscae;

scapus crassus articulo 3° parum brevior; articuli 3–5 apice breviter aculeati. Prothorax latus, convexus, subglobosus, flavido-tomentosus, maculis tribus nigris serie transversa pasitis ornatus. Scutellum magnum, nigrum. Elytra ad basin pronoto haud latiora, apicem versus leviter angustata, apice truncata angulo exteriore breviter spinoso, fasciis 4 flavido-tomentosis ornata; fascia basali lata, secunda angustior pone scutellum et ad humerum cum prima connexa maculam obliquam curvatam humeras fere tangentem sigram omnino includens; fascia 3ª lata triangula, fascia 4ª lata, apicalis. Femora haud carinata; postica elytra superantia apice bispinosa. Articulus basalis tarsorum posticorum reliquer simul sumtis parum longior. Long. corporis 14 mm.

SIBUYAN (*C. F. Baker*). Collectio Baker.

The unique specimen is probably a female.

DEMONAX TRIFASCIATUS sp. nov. Plate 1, fig. 6.

Nigro-fuscus, cinereo-pubescens; elytra fasciis tribus cinereo-albidis (basali deficiente aut valde obsoleta) ornata. Frons subplana, latitudine altior. Antennae brunneae scapo pallidiore; scapus, cylindricus articulo 3° vix brevior; articulo 3 et 4 spina longa, subfiliformi, apice obtusa armati. Prothorax supra convexus, basin et apicem versus aequaliter angustatus lateribus arcuatis, tenue cinereo-pubescens, immaculatus, ad basin anguste leviter albido-cingulatus. Scutellum fere nigram. Elytra pronoto vix latiora, brunneo-nigra, trifasciata; fascia prima antemedium sita, linearis, arcuata ad suturam usque ad scutellum producta, marginem lateralem haud ommino atterigens fascia secunda transversa, fere recta, ad suturam haud vel parum dilatata, tertia lata, apicalis. Episterna meso- et metasterni nec non segmenta duo basalia abdominis albo hirsuta, reliqua nigricantia. Pedes antici brunnei, posteriores nigro-fusci. Femora haud carinata, postica apicem elytrorum superantia. Articulus basalis tarsorum posticorum reliquis simul sumtis haud duplo longior. Long. corporis 6.5–7 mm.

NEGROS, Cuernos Mountains (*C. F. Baker*). Collectio Baker, Riksmuseum, Stockholm.

DEMONAX CORIACEOCOLLIS Aurivillius.

Demonax coriaceocollis AURIVILLIUS, Arkiv f. Zoöl. 14[18] (1922) 13, fig. 99.

MINDANAO, Kolambugan. NEGROS.

The antennæ are sometimes yellowish at base.

DEMONAX PARALLELUS Aurivillius.

Demonax parallelus AURIVILLIUS, Arkiv f. Zool. 14[18] (1922) 11, fig. 97.

MINDANAO, Kolambugan.

DEMONAX SAMARENSIS sp. nov. Plate 1, fig. 7.

Elongatus, nigricans, dense cinereo-pubescens, elytris fasciis 4 cinereo-tomentosis ornatis. Frons lata subquadrata. Antennae feminae corpore breviores fuscae, ad basin nigricantes, articulis 7–11 pallidis albidis; scapus crassus subcylindricus, articulo 3° multo brevior; articuli 3 et 4 apice spina longa, subfiliformi, apice obtusa armati. Prothorax subcylindricus, ad basin modice constrictus, dense punctulatus, utrique prope basin punctis aliquot discretis instructus, dense pubescens, nigro-bimaculatus, elytris vix angustior. Scutellum magnum, triangulare, cinereum. Elytra apice truncata, extus breviter dentata, fasciis 4 cinereis ornata; fascia basalis lata, extus haud retrorsum producta, fascia secunda linearis, usque ad scutellum producta, postice curvata; fascia tertia lata, triangula; quarta apicalis. Corpus infra dense pubescens. Femora haud carinata; postica apicem elytrorum superantia, apice breviter bispinosa. Articulus basalis tarsorum posticorum reliquis fere duplo longior. Long. corporis 14 mm.

SAMAR (*C. F. Baker*). Collectio Baker.

Described from a single female specimen.

DEMONAX SERIATOPUNCTATUS Aurivillius.

Demonax seriatopunctatus AURIVILLIUS, Arkiv f. Zool. 14[18] (1922) 12, fig. 98.

LUZON, Mount Banahao.

DEMONAX CONFINIS Aurivillius.

Demonax confinis AURIVILLIUS, Arkiv f. Zoöl. 15[25] (1923) 10.

LUZON, Mount Maquiling.

Differs from *D. seriatopunctatus* Aurivillius only by having the prothorax entirely reticulate, and may be the female of that species. Compare Gahan [4] and Schawarzer.[5]

DEMONAX ANGULIFASCIA Aurivillius.

Demonax angulifascia AURIVILLIUS, Arkiv f. Zool. 14[18] (1922) 11, fig. 101.

LUZON, Mount Maquiling and Mount Banahao.

[4] Ann. Mus. Civ. di Storia Nat. Genova III 3 (1907) 77.
[5] Suppl. Entomol. 15 (1927 60.

DEMONAX INCLUDENS sp. nov. Plate 1, fig. 8.

Nigro-fuscus, cinereo-pubescens; elytra fasciis 4 cinereis ornata, quorum prima et secunda ad suturam et extus conjunctae maculam subtrigonam nigram includentes. Antennae corpore multo (♂) vel vix (♀) longiores, articulis 3 vel 4 ultimis albidis; spinae articuloram 3 et 4 longae, filiformes, apice obtusae. Prothorax elongatus, ad basin constrictus, latitudino longior, elytris param angustior, dense granulato-punctatus, in maribus saepe lineis 2–3 elevatis leviter granulatis instructus, maculis duobus nigris interdum connexis, ornatus. Scutellum cinereum. Elytrorum fascia 2ª marginem haud attingens ad suturam pone scutellum et extus pone humeram cum fasciam basalem connexa, maculam nigram includens; fascia 3ª antice ad suturam plus minusve producta et acuminata; fascia apicalis antice rotundata vel subtruncata. Femora haud carinata; postica apicem elytrorum sat longe superantia, apice breviter bispinosa. Articulus basalis tarsorum posticorum reliquis simul sumtis fere duplo longior. Long. corporis 8–13 mm.

SIBUYAN. SAMAR. NEGROS (*C. F. Baker*). Collectio Baker. Riksmuseum, Stockholm.

Easily distinguished from *Demonax angusticollis* by the form of the included subbasal black spot of the elytra and the blunt spines of the elytra.

Genus OLIGOENOPLUS Chevrolat

One species only is known from the Philippine Islands.

OLIGOENOPLUS LUZONICUS Schwarzer.

Oligoenoplus luzonicus SCHWARZER, Ent. Mitt. 15 (1926) 9.

LUZON, Imugan and Mount Banahao.

Black with white markings. Hind border of pronotum and three spots on each elytron white; first spot transverse before the middle, second linear forming a curved transverse fascia behind the middle and produced at the suture; third large, apical. Femora strongly punctured, not carinate. Prothorax and legs with erect hairs. Length, 7 to 9 millimeters.

Genus SCLETHRUS Newman

(*Neocollyrodes* W. Schultze)

This genus is distinguished from all other Philippine genera of Clytini by the elytra being convex posteriorly and strongly sloping at apex. Antennæ with joints 3 and 4 spined at apex, the spines short. Femora not carinate. First tarsal joint of hind legs longer than the following joints together.

Key to the species of Sclethrus Newman.

a^1. Pronotum with four bluish white dots, two near base, two at middle. Elytra in basal part to behind middle dark and opaque, densely covered with deep punctures.. *S. amoenus* Gory.

a^2. The dots of the pronotum on each side united to a white or bluish stripe. Elytra in basal part subnitid, greenish or bluish with smaller and more distant punctures................................ *S. newmani* Chevrolat.

The species are somewhat variable and only doubtfully distinct.

SCLETHRUS AMOENUS Gory.

Ibidion amœnum GORY, Mag. de Zoöl. 3 (1833) Ins. t. 58.

Sclethrus amœnus PASCOE, Trans. Ent. Soc. London III 3 (1869) 619.

LUZON. (?) MINDANAO. SIBUYAN.

SCLETHRUS NEWMANI Chevrolat.

Sclethrus newmani CHEVROLAT, Mém. Soc. Sc. Liége 18 (1863) 284 (sep. 32).

Neocollyrodes mcgregori W. SCHULTZE, Philip. Journ. Sci. 16 (1920) 196, pl. 1, fig. 2.

LUZON. MINDANAO.

ILLUSTRATIONS

Plate 1

1. *Xylotrechus humeralis* sp. nov.
2. *Xylotrechus luzonicus* sp. nov.
3. *Demonax virescens* sp. nov.
4. *Demonax angusticollis* sp. nov., type.
5. *Demonax robustus* sp. nov.
6. *Demonax trifasciatus* sp. nov.
7. *Demonax samarensis* sp. nov.
8. *Demonax includens* sp. nov.

PLATE 1.

COCCIDÆ OF FORMOSA

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ONE PLATE

INTRODUCTION

The family Coccidæ is very rich in species and these are mostly decidedly polyphagous, attacking fruit and ornamental trees, as well as other cultivated plants, and sometimes causing serious damage to them. For example, *Icerya purchasi* Mask., *I. aegyptiaca* Dougl., *I. seychellarum* Westw., *Pseudococcus citri* Risso, *P. adonidum* Linn., *P. lilacinus* Ckll., *P. filamentosus* Ckll., *Trionymus sacchari* Ckll., *Ferrisia virgata* Ckll., *Pulvinaria psidii* Mask., *Coccus viridis* Green, *Saissetia hemisphaerica* Targ., *S. formicarii* Green, *Aulacaspis cinnamoni* Newst., *Chrysomphalus aonidum* Linn., *Parlatoria ziziphus* Lucas, and several others are among the worst pests, and there are now twenty-four species of these insects known to occur on *Citrus* and six on sugar cane in Formosa.

Notwithstanding their economic importance, the insects of this family in Formosa have never been thoroughly studied by any entomologist, only about fifty species having been recorded by Chamberlin, Ferris, Green, Kuwana, Maki, Maskell, Shiraki, and others from the island; numerous species of economic importance remain undetermined or misidentified.

The present paper is the first report of my studies on this group of insects in Formosa. Fifty species and two varieties of the non-diaspine Coccidæ are here recorded, of which five species and one variety seem to be new to science.

The food plants recorded in this paper are only those which have been ascertained by me to be fed upon by each species in Formosa. All the material, including the types, examined by me will be preserved in the entomological laboratory, Department of Agriculture, Government Research Institute, Taihoku, Formosa.

I express here my cordial thanks to Prof. S. Isshiki and Dr. T. Shiraki, for their kind help in various ways; and to Dr. J. C. Chamberlin, Mr. E. E. Green, and Dr. I. Kuwana, for their kindness in examining some of my specimens. I am also very much indebted to Messrs. S. Akasaka, Y. Horikawa, M. Kato, M. Matsuda, H. Sakurai, K. Sawada, J. Sonan, S. Takano, K. Toyota, and M. Yanagihara, who have been kind enough to collect valuable specimens for me. Mr. F. C. Hadden, of the Sugar Experiment Station at Honolulu, Hawaii, has kindly corrected errors in English in a part of the manuscript of this paper and I extend my sincere gratitude to him.

MONOPHLEBINÆ

DROSICHA MASKELLI Cockerell.

Drosicha maskelli (Cockerell), MORRISON, Proc. U. S. Nat. Mus. 62, Art. 17 (1923) 2.

Host.—*Ficus retusa.*

Habitat.—Taihoku.

Hitherto unrecorded from Formosa. Some adult females and grown nymphs were collected by me in January, February, April, and December, the characters of which answer closely to Morrison's description and figures of Cockerell's species. The antennæ are usually 8-jointed, but 7-jointed in some examples. Some of my specimens have been kindly examined by Mr. Green.

DROSICHA CONTRAHENS Walker.

Drosicha contrahens Walker, GREEN, Ann. & Mag. Nat. Hist. IX 12 (1923) 168.

Host.—*Persea gratissima.*

Habitat.—Kagi.

Previously known only from China. Some adult females were collected by Mr. K. Toyota on May 14, 1927. These specimens agree with Green's redescription and figures of the type. The antennæ are 8-jointed; the fifth joint is almost as large as the fourth; the sixth and the seventh with rounded sides, the sixth somewhat smaller than the fifth, but somewhat larger than the seventh; the eighth a little longer than the sixth and the seventh taken together, swollen on the basal one-third.

Some males of a *Drosicha* collected on June 3, 1927, at Kagi, Formosa, may belong to this species. They are allied to *Monophlebus philippinensis* Green,[1] but differ from it in possessing five pairs of much longer appendages on the abdomen.

[1] Not. Ent. 4: 2.

DROSICHA DALBERGIAE Green.

Monophlebus dalbergiae GREEN, Ind. Mus. Not. 5 [2] (1902) 101; Proc. 5th Ent. Meet. Pusa 1923 (1924) 338.

Drosicha dalbergiae VAYSSIERE, Ann. Epiph. 12 (1926) 274.

Host.—Unknown.

Habitat.—Tansui.

Hitherto recorded only from India. Two females were collected by the late Mr. Nitobe in January, 1910. These specimens agree with Vayssiere's notes and figures.

ICERYA AEGYPTIACA Douglas.

Hosts.—*Artocarpus incisa, Celtis* sp., *Croton* sp., *Mallotus philippensis, Psidium guyava, Psychotria elliptica.*

Habitat.—Shirin, Tainan, Heito, Taito, Chippon.

This species is very common in the southern half of Formosa, but is quite rare in the northern.

ICERYA SEYCHELLARUM Wood.

Hosts.—*Areca catechu, Chrysophyllum cainito, Citrus* spp., *Eugenia javanica, Ficus wightiana, Maba buxifolia, Mangifera indica, Machilus* sp., *Morus alba, Podocarpus macrophylla, Persea gratissima, Psidium guyava, Sapium sebiferum.*

Habitat.—Taihoku, Shinten, Tosei, Kagi, Tainan, Botel Tobago.

Very common throughout Formosa.

ICERYA PURCHASI Maskell.

Hosts.—*Acacia confusa, Artemisia capillaris, Citrus* spp., *Rosa* sp., *Vitex negundo.*

Rather common throughout the island, sometimes occurring in large numbers in July and August. More than seventy species of plants in about thirty families have been recorded as being fed upon by this insect in Formosa, of which *Acacia confusa, Citrus* spp., and *Artemisia capillaris* are most favored. This pest was imported into the island about twenty-five years ago and caused serious damage to *Acacia confusa* and other plants, but since the introduction of its enemy, *Novius cardinalis,* in 1909, it has been kept in check.

DACTYLOPIINÆ

PSEUDOCOCCUS CITRI Risso.

Hosts.—*Artocarpus incisa, A. integrifolia, Acacia confusa, Calathea tubispatha, Carludovica palmata, Clausena wampi, Citrus* spp., *Lespedeza* sp., *Morus alba, Persea gratissima, Psidium guyava, Tectona grandis, Tetrapanax papyrifera, Thea chinensis.*

Habitat.—Hokuto, Taihoku, Kagi, Shinkwa, Heito, Karenko, Riran, Taito, Koshun.

Very common in almost any season.

PSEUDOCOCCUS ADONIDUM Linnæus.

Hosts.—*Areca catechu, Citrus* sp., *Ficus retusa, Prunus communis.*

Habitat.—Tansui, Taihoku, Heito.

This species is very common in Formosa and is most so on *Ficus retusa* in summer. *Pseudococcus longispinus* Targ. is generally considered to be a synonym of this species, and the Formosan specimens agree well with the descriptions of that species given by several investigators, but differ from Green's description and figures of it [2] in the following characters: Tibia of middle leg about 2.5 as long as tarsus; setæ of anal ring distinctly stouter than anal setæ.

PSEUDOCOCCUS COMSTOCKI Kuwana.

This species was recorded by G. F. Ferris [3] from *Citrus* in Formosa, but I have never collected it in the island.

PSEUDOCOCCUS LILACINUS Cockerell.

Hosts.—*Callicarpa formosana, Croton* sp., *Gardenia florida, Heritiera littoralis, Macaranga* sp., *Mallotus japonicus, Mallotus* sp., *Rhododendron* sp., *Terminalia* sp.

Habitat.—Hokuto, Taihoku, Shinten, Taichu, Kagi, Toko, Domon, Karenko.

Hitherto unrecorded from Formosa. This species is very common near Taihoku, and its colonies are almost always protected by *Cremastogaster rogenhoferi* (Formicidæ). Some of my specimens have been compared with material from Ceylon by Mr. Green.

PSEUDOCOCCUS BREVIPES Cockerell.

Host.—*Ananas sativus.*

Habitat.—Shirin, Kagi, Hozan.

New to Formosa. This species is common on the pineapple, but is not a serious pest.

PSEUDOCOCCUS FILAMENTOSUS Cockerell.

Hosts.—*Artocarpus integrifolia, Broussonetia papyrifera, Citrus* spp., *Coffea arabica, Ficus retusa, Gardenia florida, Mussaenda luteola, Nerium odorum, Zizyphus* sp.

[2] Cocc. Ceylon 5: 383.

[3] Bull. Ent. Res. 12: 211.

Habitat.—Taihoku, Kagi, Heito.

Near Taihoku this species is very common; it is most abundant in summer.

PSEUDOCOCCUS SACCHARICOLA sp. nov. Plate 1, fig. 1.

Adult female.—Yellowish brown. Body oval, covered with white secretion not forming tassels. Antennæ 8-jointed, with some bristles which are almost as long as, or longer than, the fourth antennal joint; the first joint as long as wide, stouter than the second; the second a little stouter than the third, with a very small circular sensorium at the apex; the second and the third almost cylindrical, but the fourth, the fifth, and the seventh narrowed towards the base; the eighth as long as the front tarsus, with longer bristles; the relative length of joints about as follows: I, 13; II, 15; III, 12; IV, 6; V, 9; VI, 6; VII, 9; VIII, 21. Eyes almost marginal, as large as the fourth antennal joint. Beak conical, 2-jointed, a little longer than wide. Legs usual; hind coxæ with numerous minute pores over the whole length; trochanters with four bristles of which one at the apex is much longer; femora with some bristles of which two are a little longer; hind femora as long as the tibia, with some faint areolations; tibiæ about twice as long as the tarsus in the front legs, but 2.4 times in the hind legs, with some bristles of which two near the apex are much stouter, but are a little shorter; hind tibiæ with about twenty minute pores mostly on the distal half, of which one or two near the distal end are sometimes larger; claws without denticles; tarsal digitules long, slender, scarcely knobbed, but those of the claw distinctly knobbed, longer than the claw. Hind spiracles somewhat larger than the front. Series of cerarii almost complete, one pair on the head and fourteen or fifteen posterior pairs present; each of those on the head composed of more than ten small triangular pores, an accessory seta and three spines one of which is sometimes longer; the apical abdominal pair each large, with two or three spines of equal length, a loose cluster of many tringular pores and several long bristles, not underlaid by any definite chitinous thickening, the spines about 2.7 times as long as wide, somewhat shorter than the hind claw; the penultimate pair each with two spines which are much smaller than those of the last pair, but longer than those of the remaining pairs; all the antepenultimate pairs each with two or rarely three spines, about eight to ten triangular pores and one or more accessory setæ; these spines almost equal in length. Anal lobes hardly protruding, apical setæ very

long, about 1.5 times as long as the seta of the anal ring, a little shorter than the hind tibia. Anal ring usual, with two rows of pores and six setæ which are longer than the diameter of the ring. Body with numerous pores of two types and ducts; triangular pores small, numerous, distributed over the dorsum and venter; large multilocular pores confined to the ventral abdominal region, in a large cluster around the genital opening and two transverse rows anterior to the genital cluster; these rows and cluster not reaching the body margin; tubular ducts short, distributed over the dorsum and venter of the abdomen, abundant on the posterior portion and on the side. Body with some bristles of various length which are mostly shorter than the first antennal joint. Ventral cicatrix not distinct. Anterior and posterior glandular foveæ distinct.

Length of body, about 2.5 to 3 millimeters; antenna, about 0.415; hind tibia, about 0.268.

Host.—*Saccharum officinarum,* attacking the lower side of the leaf.

Habitat.—Shinkwa.

A few specimens were collected in August, 1927, by Mr. S. Takano, who writes me that this species sometimes occurs in large numbers on sugar cane in green houses at Shinkwa. This species is very closely allied to *Pseudococcus boninsis* Kuwana, the distribution of the pores on the body agreeing almost exactly with Morrison's description and figure of Kuwana's species,[4] but is distinguishable from it by the number of the cerarii, as well as by the characters of the antennæ. This species is also closely related to *Pseudococcus variabilis* Hall and *P. calceolariæ* Mask., but is different from them in the number of the cerarii, the shorter setæ of the anal ring, or the distribution of the pores on the body.

TRIONYMUS DIMINUTUS Leonardi.

Trionymus diminutus MORRISON, Journn. Agr. Res. 31 (1925) 495.

Host.—*Saccharum officinarum.*

Habitat.—Kori, Byoritsu.

Hitherto unrecorded from Formosa. Many adult females were collected by Mr. M. Yanagihara in May and November. Some specimens are not provided with pores on the hind femora and trochanters.

[4] Journ. Agr. Res. 31: 490.

TRIONYMUS SACCHARI Cockerell.

Pseudococcus sacchari MORRISON, Philip. Journ. Sci. 17 (1920) 173.
Trionymus sacchari MORRISON, Journ. Agr. Res. 31 (1925) 497.

Hosts.—*Saccharum officinarum, Miscanthus* sp.

Habitat.—Kori, Shinkwa.

This species is very common at Shinkwa, causing serious damage to sugar cane, but is hitherto unrecorded from Formosa. The spines in the last cerarus are usually two in number, but there are three in a few examples in my collection; the antennæ are 7- or 8-jointed.

TRIONYMUS PULVERARIUS Newstead var. **BAMBUSAE** Green.

Pseudococcus pulverarius Newstead subsp. *bambusae* GREEN, Cocc. Ceylon 5 (1922) 374.

Host.—*Bambusa stenostachya.*

Habitat.—Taihoku.

Previously known only from Ceylon. Many adult and immature females were collected by me in September, 1927. They were concealed between the stipules and the stalk of a young shoot. The adult possesses large circular multilocular pores distributed over the body, but abundant around the genital opening, some very short ducts on the posterior portion, some small triangular pores, and a quadrate cicatrix with rounded corners at the middle of the abdomen. This species is related to *T. diminutus* Leonardi, but is distinguishable from it by the number of the cerarii on the posterior abdominal segments, as well as by the shorter tibiæ. I have no specimens from Ceylon for comparison, but the Formosan ones answer to Green's figures and description.

TRIONYMUS MISCANTHI sp. nov. Plate 1, fig. 2.

Adult female.—Yellowish brown, with a slightly pinkish tinge. Body oval, about twice as long as wide in mounted specimens, somewhat convex on the dorsum, covered with white powder, the secretion forming no tassels. Eyes very small, smaller than the shortest antennal joint, marginal. Antennæ small, 6-jointed, provided with some bristles which are as long as, or longer than, the fourth antennal joint; the first joint much stouter than the second; the second and the third somewhat longer than wide; the fourth very slightly wider than long; the fifth narrowed towards the base; the sixth slightly longer than the tarsus, with some longer bristles; the relative length of joints about as follows: I, 9; II, 7; III, 6; IV, 4; V, 5; VI, 12. Beak stout, conical, 2-

jointed, almost as long as wide. Legs small, with a few hairs; hind coxæ with numerous rather large or medium-sized circular pores mostly on the basal half; trochanters with a very long bristle at the apex which is as long as the trochanter; femora almost as long as tibia and tarsus taken together, without areolations; tibiæ about 1.5 times as long as the tarsus, lacking pores, with about five bristles of which two near the tip are sometimes slightly stouter; tarsal digitules very long, but shorter than the tarsus, slightly knobbed; claws without denticles, the digitules slender, knobbed. Spiracles stout, without pores on the sides of orifice; the hind pair slightly larger than the front. Cerarii present only on the last two segments; the last pair each with two spines which are a little shorter than the hind claw and two accessory long bristles, but without pores, not underlaid by a definite chitinous thickening; the penultimate pair each with two or sometimes one spine which are as long as, or a little shorter than, those of the last pair, and two bristles; two or three antepenultimate segments each with a spine on the side. Anal lobes slightly protruding, with a very long seta which is shorter than the antenna, almost as long as the hind tibia and tarsus taken together. Anal ring with pores almost in two rows and six setæ which are almost as long as, but slightly stouter than, the apical seta. Body with many circular multilocular pores of almost equal size, but lacking triangular pores and tubular ducts; multilocular pores distributed over the dorsum and venter, numerous along the side and around the spiracles and abundant around the genital opening, but very few on the middle areas of the dorsum and venter, those around the spiracles variable in size. Body with some bristles, of which those on the posterior portion, especially around the genital opening area, are stouter. Anterior dorsal glandular foveæ absent, the posterior ones rather small. Abdomen with four or five very large oval cicatrices in a longitudinal row, of which the anterior one is smaller; the larger ones larger in diameter than the anal ring or the glandular fovea, about 0.074 millimeter in the largest diameter.

Length of body, about 4 millimeters; antenna, about 0.189; hind tibia, about 0.0766.

Host.—*Miscanthus* sp.

Habitat.—Taihoku.

This species is closely allied to *Trionymus pulverarius* Newstead, but is distinguishable from it by the stouter body, as well as by possessing large circular cicatrices on the abdomen and

only multilocular circular pores of almost equal size on the body. It is different from all other species of the genus in the wider body. Individuals of this species are abundant near Taihoku; they are found concealed between the stalks and the basal parts of the leaves of the host plant, and are sometimes protected by ants of the genus *Cremastogaster.*

RIPERSIA CELLULOSA Hall.

Ripersia cellulosa HALL, Minist. Agr. Egypt. Tech. Sci. Serv., Bull. 36 (1923) 7; Bull. 72 (1926) 30.

Host.—*Bambusa* sp.

Habitat.—Taihoku.

Hitherto known only from Egypt. This species is found between the stalk and the stipules of the host. The Formosan specimens differ from the type in having a series of four conspicuous oval medioventral cicatrices, but otherwise the characters agree completely. Mr. Green has kindly compared the specimens with the type.

FERRISIA VIRGATA Cockerell.

Pseudococcus virgatus FERRIS, Journ. Econ. Ent. 12 (1919) 297; MORRISON, Philip. Journ. Sci. 17 (1920) 171; FERRIS, Bull. Ent. Res. 12 (1921) 211; GREEN, Cocc. Ceylon 5 (1922) 371.

Ferrisia virgata FULLAWAY, Proc. Hawaii. Ent. Soc. 5 (1923) 311; MORRISON, Journ. Agr. Res. 31 (1925) 497.

Hosts.—*Acalypha* sp., *Anona squamosa, Calliandra haematocephala, Casuarina equisetifolia, Croton* sp., *Eugenia javanica, Bauhinia* sp., *Inocarpus edulis, Persea gratissima, Psidium guyava, Punica granatum, Thea japonica.*

Habitat.—Tosei, Kagi, Kwanshirei, Shinkwa, Tainan, Heito, Koshun, Taito, Karenko.

Very common in the southern half of Formosa, but has never been collected in the northern.

PHENACOCCUS SPINOSUS Robinson.

Phenacoccus spinosus ROBINSON, Philip. Journ. Sci. 13 § D (1918) 145; GREEN, Cocc. Ceylon 5 (1922) 394.

Puto spinosus MORRISON, Philip. Journ. Sci. 17 (1920) 165.

Host.—Unknown.

Habitat.—Hatsune near Karenko.

This species has never been recorded from Formosa. I observed this species entirely covering the stem and branches of a large tree at Hatsune on November 13, 1925. The species is peculiar in the truncate spines on the body, being provided

with thirty-four spiniferous marginal cerarii and in a denticle on the inner edge of the claw.

PHENACOCCUS HIRSUTUS Green.

> *Phenacoccus hirsutus* GREEN, Mem. Dept. Agr. Ind. II 2 (1908) 25; MORRISON, Philip. Journ. Sci. 17 (1920) 169; HALL, Minist. Agr. Egypt. Tech. Sci. Serv., Ent. Ser., Bull. 17 (1921) 1–28.

Hosts.—*Morus alba, Hibiscus* sp.

Habitat.—Hokuto, Taihoku.

Hitherto known from India, Egypt, Tasmania, and the Philippine Islands, and new to Formosa. This species is rather scarce in Formosa, though it is a serious pest in Egypt. *Phenacoccus hirsutus* Green var. *cressae* Hall and the allied species, *P. glomeratus* Green, are not found in Formosa.

Genus MIZOCOCCUS novum

Adult female.—Subterranean, forming a complete sac. Body globular, the ventral side longitudinally deeply sunken. Antennæ small, not stout, 6-jointed, not placed close together. Mentum 2-jointed. Legs small, usual in structure. Anal ring rather small, placed a little distant from the posterior extremity, with six setæ and many pores almost in two rows. Derm rather hard throughout, with many small triangular pores, lacking tubular ducts and larger pores. Cerarii not developed, only the last abdominal pair represented by a few spinelike setæ. Anal lobes absent, but a pair of long setæ present near the posterior extremity. Dorsal glandular foveæ small.

Genotype, *Mizococcus sacchari* sp. nov.

This genus is very peculiar and is apparently distinct from other proposed genera. *Mizococcus sacchari* sp. nov. is known to entomologists in Formosa under the Japanese name of "Mizo-kaigara," from which the generic name has been derived.

MIZOCOCCUS SACCHARI sp. nov. Plate 1, fig. 3.

Adult female.—Lemon yellow with a pinkish tinge, or pink, slightly covered with white powder. Subterranean, forming a sac as in *Geococcus radicum* Green. Body almost globular, the ventral side longitudinally deeply sunken; division of segments indicated on the dorsum by moderately deep transverse furrows; longitudinally somewhat convex on the middle of the dorsum where the furrows are obscure. Derm rather hard throughout, more chitinized than in *Pseudococcus* and its allies, without cicatrices on the ventral side. Eyes marginal, very small, smaller than the fourth antennal joint. Antennæ small, not stout,

a little longer than tibia and tarsus taken together, 6-jointed, with some rather stout setæ which are nearly as long as the fourth antennal joint, situated on the ventral side near the front, not placed close together; the first joint much stouter than the second; the second longer than wide; the third somewhat narrowed towards the base; the fourth and the fifth almost as long as wide, constricted at the base; the sixth slightly shorter than the tarsus, with some longer setæ at the apex; the relative length of joints about as follows: I, 8; II, 8; III, 9; IV, 5; V, 6; VI, 15. Beak stout, conical, somewhat longer than wide, 2-jointed; the basal joint with a pair of rather long bristles near the distal end on the lower surface; the apical joint with two pairs of bristles on the upper surface and eight pairs on the distal part of the lower side, of which a pair almost on the side is much longer. Spiracles lacking pores, the hind ones very slightly larger than, but similar in shape to, the front. Legs short, with some rather long setæ; trochanters with five long setæ of which one near the apex is much longer; femora stout, swollen, slightly longer than the tibia; tibiæ very slightly longer than the tarsus, with two stout setæ near the apex, wanting pores; tarsi without knobbed hairs; claws with no denticle, digitules slender, scarcely knobbed. Anal ring rather small, about 0.074 millimeter in diameter, situated a little distant from the posterior end of the abdomen, with six very stout setæ which are shorter than the diameter of the anal ring, and more than seventy small circular pores arranged almost in two rows, pores in the outer row not regularly arranged. Anterior and posterior dorsal glandular foveæ inconspicuous, smaller than the anal ring. Body with many very small triangular pores scattered over the surface and numerous on the side, lacking tubular ducts and larger pores. Only the last abdominal cerarii present, each composed of two or three spinelike setæ which are shorter and more slender than the seta of the anal ring, and seven or eight pores similar to those on other parts of the body, not underlaid by any chitinous thickening nor more chitinized. Anal lobes not developed. Abdomen near the posterior extremity with a pair of long setæ which are nearly as long as the hind tibia, and much longer, but more slender, than the seta of the anal ring. Body with some setæ of various lengths on the side and venter, the longer ones almost as long as the sixth antennal joint; the dorsum scarcely with shorter setæ.

Length of body, about 4 millimeters; antenna, about 0.23; hind tibia, about 0.11.

First instar.—Body somewhat elongate ovate, about twice as long as wide in mounted specimens, with many setæ and small triangular pores mostly on the dorsum. Antennæ somewhat longer than tibia and tarsus taken together; 6-jointed, with long setæ which are longer than the third antennal joint; the relative length of joints about as follows: I, 6; II, 7; III, 5; IV, 5; V, 5; VI, 15. Legs stout; femora slightly longer than the tarsus; tarsi slightly longer than the tibia, without capitate hairs. Anterior and posterior dorsal glandular foveæ present. Anal ring with six (?) setæ. Anal lobes scarcely protruding, each with an apical seta which is almost twice as long as the seta of the anal ring. Last cerarii each represented by two spinelike setæ which are much shorter than the seta of the anal ring.

Length of body, about 1 millimeter; antenna, about 0.2.

Hosts.—*Saccharum officinarum, Miscanthus* sp., a plant of the Gramineæ.

Habitat.—Kori.

Some specimens attached to roots were collected by Mr. M. Yanagihara in May and July.

This species is common on the hosts and is very injurious to the sugar cane. The color notes were made by Mr. M. Yanagihara. In an adult female in my collection the anal ring has seven setæ. Some of my specimens have been kindly examined by Mr. Green.

ANTONINA CRAWI Cockerell.

Antonina crawi COCKERELL, Psyche 9 (1900) 70; KUWANA, Illust. Mon. Japan Cocc. 2 (1917) 127; FERRIS, Bull. Ent. Res. 12 (1921) 211.

Host.—*Bambusa* sp.

Habitat.—Taihoku.

In Formosa this species is very rare, some specimens having been collected by Mr. M. Maki long ago.

ANTONINA INDICA Green.

Antonina indica GREEN, Mem. Dept. Agr. Ind. Ent. Ser. II 2 (1908) 27; Cocc. Ceylon 5 (1922) 395.

Host.—A plant of the Gramineæ.

Habitat.—Kori, Taihoku.

Previously known only from India, Ceylon, and Hawaii, and a variety of it from Egypt. Some adult females were collected by Mr. M. Yanagihara at Kori and by Mr. M. Kato at Taihoku.

ANTONINA BAMBUSAE Maskell.

Antonina bambusae FERRIS, Bull. Ent. Res. 12 (1921) 211; GREEN, Cocc. Ceylon 5 (1922) 397.

Chaetococcus bambusae MORRISON, Proc. U. S. Nat. Mus. 60, Art. 12 (1922) 55.

Host.—*Bambusa stenostachya.*

Habitat.—Taihoku.

Near Taihoku this species is rather rare, occurring in restricted numbers.

ASTEROLECANIINÆ

ANOMALOCOCCUS MULTIPORI Morrison.

Anomalacoccus multipori MORRISON, Philip. Journ. Sci. 18 (1921) 641.

Hosts.—*Glochidion fortunei, G. hypoleuca, Glochidion* sp., *Adinandra formosana.*

Habitat.—Sozan, Taihoku.

Previously recorded only from Singapore. Near Taihoku this species is very common on *Glochidion* and is always found in the nest of *Cremastogaster rogenhoferi* (Formicidæ). Some of my specimens have been kindly examined by Mr. Green.

CEROCOCCUS FICOIDES Green.

Cerococcus ficoides GREEN, Ent. Mth. Mag. II 10 (1899) 225; Mem. Dept. Agr. Ind. I 5 (1907) 338; FERRIS, Bull. Ent. Res. 12 (1921) 212.

Hosts.—*Ficus retusa,* attacking the aid root; *Gardenia florida, Mallotus japonicus, Thea chinensis.*

Habitat.—Taihoku, Heitin, Koheki.

This species is rather common.

ASTEROLECANIUM BAMBUSAE Boisduval var. **TUBERCULATA** var. nov.

Adult female.—Differs from typical *A. bambusae* Boisd. in the presence of a transverse tubercular ridge across about the middle of the scale, as well as in lacking paired pores on the dorsum.

Host.—*Bambusa,* attacking the stalk.

Habitat.—Taihoku.

Very common near Taihoku. Typical *A. bambusae* has never been collected in Formosa. The new name has been suggested by Mr. Green who has kindly compared Formosan specimens with some representing the typical species.

ASTEROLECANIUM CORALLINUS sp. nov. Plate 1, fig. 4.

Adult female.—Test dark green, almost circular, not narrowed nor elevated at the posterior extremity, flattened, with no fur-

rows and ridges, with numerous short whitish filaments over the surface, the margin with a complete fringe of long coral red filaments.

Body almost circular, somewhat narrower on the posterior end, with about one hundred forty pairs of pores arranged in a single row on the whole margin excepting the posterior extremity, these paired pores of equal size, somewhat larger than those on the dorsum; a single ventro-marginal row of simple minute circular pores present close to the marginal row of the paired pores; another single row of simple minuter circular pores present along the whole margin on the ventral side; the dorsum with many paired pores of equal size scattered over the surface excepting the middle area of the apical portion of the abdomen, intermixed with very minute paired pores scattered over the whole surface, and with numerous long tubular ducts distributed over the whole surface, these ducts of equal length, very slightly dilated towards the base, scarce in number on the apical portion of the abdomen; the venter with a few very short setæ along the margin and four transverse irregular rows of circular pores on the middle area of the posterior portion of the abdomen, these pores somewhat variable in size, the larger ones almost as large as the dorsal paired pore, about sixty-five in number in all. Antennæ very small, not jointed, submarginal, much smaller than the spiracle, wider than long, broadly rounded on the apex, with a few short and two much longer setæ, the longer ones longer than the antenna, but shorter than the tubular duct on the dorsum. Spiracles stout, nearly as long as wide, at a considerable distance from the margin, of equal size, almost as long as the tubular duct on the dorsum, with about ten or thirteen very small pores in a cluster on the side of the orifice; many similar pores connecting the spiracles with the margin. Abdominal extremity slightly cleft; anal lobes stout, with about four very short setæ; apical setæ very long, stout, about three times as long as the tubular duct on the dorsum. Anal ring with six long stout setæ which reach the margin, but are shorter than the apical seta.

Length of body, about 0.807 millimeter; antenna, about 0.0095; tubular duct on dorsum, about 0.023; apical seta, about 0.07; test, about 1.1; marginal filament, about 0.166.

Host.—*Sideroxylon ferrugineum*, attacking the twig.

Habitat.—Keelung.

Very common in August on this host near the beach. Some of my specimens have been kindly examined by Mr. Green.

COCCINÆ

COCCUS HESPERIDUM Linnæus.

Hosts.—*Carica papaya, Citrus* sp., *Thea chinensis.*

Habitat.—Keelung, Taihoku, Sankyo, Gyochi, Tainan, Hozan.

This species is rather rare in Formosa, but I observed it in large numbers on a papaya fruit at Tainan in October. The colonies of this *Coccus* are sometimes found in the nests of *Cremastogaster rogenhoferi* (Formicidæ).

COCCUS BICRUCIATUS Green.

Lecanium bicruciatus GREEN, Cocc. Ceylon (1904) 214.
Coccus bicruciatus FERRIS, Bull. Ent. Res. 12 (1921) 212.

Host.—*Murraya exotica.*

Habitat.—Taihoku.

In Formosa this species is very rare, and no specimens have been discovered by me.

COCCUS VIRIDIS Green.

Hosts.—*Achros sapota, Aegle marmelos, Citrus* sp., *Carissa* sp., *Clausena lunulata, Coffea arabica, Gardenia florida, Genipa americana, Heritiera littoralis, Ixora chinensis, Plumeria acutifolia, Psidium guyava.*

Habitat.—Kagi, Heito.

Very common in Kagi, but has never been collected in the northern part of the island.

COCCUS ACUMINATUS Signoret.

Lecanium acuminatus GREEN, Cocc. Ceylon (1904) 195.

Host.—*Gardenia florida.*

Habitat.—Taihoku.

Hitherto unrecorded from Formosa. A few adult females with from 6- to 8-jointed antennæ were collected by me on the lower sides of the leaves.

COCCUS MANGIFERAE Green.

Lecanium mangiferae GREEN, Ent. Mth. Mag. 25 (1889) 249; Cocc. Ceylon (1904) 216.
Coccus mangiferae MORRISON, Philip. Journ. Sci. 17 (1920) 190.

Host.—*Psychotria elliptica.*

Habitat.—Taihoku.

New to Formosa. A few adult females were collected by me in August.

COCCUS CAUDATUS Green.

Lecanium caudatum GREEN, Ind. Mus. Not. 4 (1896) 10; Cocc. Ceylon (1904) 223.

Host.—Unknown.

Habitat.—Toyohara.

Previously recorded only from Ceylon. An adult female was taken by Mr. M. Kato on September 1, 1927.

COCCUS ELONGATUS Signoret.

Hosts.—*Acacia confusa, Anona squamosa, Codiaeum variegatum, Calliandra haematocephala, Casuarina equisetifolia, Citrus* spp., *Derris laxiflora, Hibiscus rosasinensis, Morus alba, Myrica rubra, Nephelium litchi, Osmanthus fragrans, Pithecolobium dulce, Pometia pinnata, Rhus* sp.

Habitat.—Taihoku, Itabashi, Kagi, Heito, Karenko, Tamasato, Botel Tobago.

This species is very common in Formosa, sometimes occurring in large numbers. The specimens on *Citrus* spp. are a little smaller and are mostly form *frontale* Green, but the long series of them shows a complete chain connecting *frontale* Green with *elongatus* Signoret.

SAISSETIA HEMISPHAERICA Targioni Tozzetti.

Hosts.—*Adiantum coneatum, Adiantum* sp., *Anona* sp., *Ardisia quinquegona, Bischoffia javanica, Carissa carandas, Chrysophyllum cainito, Citrus* spp., *Cucurbita moschata, Cycas revoluta, Eugenia unifolia, Ficus wightiana, Gardenia florida, Ixora chinensis, Lagerstroemia indica, Mangifera indica, Psidium guyava, Plumeria acutifolia, Psychotria elliptica, Osmanthus fragrans, Rhus vernicifera, Rhus* sp., *Tabernaemontana* sp., *Thea chinensis.*

Habitat.—Tansui, Taihoku, Urai, Itabashi, Heitin, Koheki, Kori, Kagi, Shinkwa, Heito, Koshun, Taito, Chippon, Botel Tobago.

Very common in Formosa; sometimes protected by *Cremastogaster rogenhoferi* (Formicidæ).

SAISSETIA NIGRA Nietner.

Hosts.—*Ardisia quinquegona, Artemisia capillaris, Bischoffia javanica, Canna indica, Chrysophyllum cainito, Citrus* sp., *Croton* sp., *Ficus carica, F. gibbosa, F. retusa, Ficus* sp., *Gossypium herbaceum, Psidium guyava, Sapium sebiferum, Terminalia catappa,* a plant of the Leguminosæ.

Habitat.—Tansui, Taihoku, Tainan, Heito, Karenko, Taito, Botel Tobago.

Very common in Formosa, but found in small numbers.

SAISSETIA OLEAE Bern.

Hosts.—*Gossypium herbaceum, Nerium odorum, Terminalia catappa.*

Habitat.—Taihoku.

Very rare, and occurring in very small numbers.

SAISSETIA FORMICARII Green.

Lecanium formicarii GREEN, Cocc. Ceylon (1904) 190.

Hosts.—*Aglaia odorata, Bischoffia javanica, Cinnamomum camphor, C. ceylanicum, Diospyros kaki, Eugenia javanica, Ficus vasculosa, F. wightiana, Gordonia axillaris, Heptapleurum octophyllum, Eriodendron anfractuosum, Grevillea robusta, Lagerstroemia flos-reginae, Machilus* sp., *Mangifera indica, Michelia alba, Michelia* sp., *Melicope triphylla, Olea europea, Palaquium formosanum, Persea gratissima, Quercus* sp., *Rhus* sp., *Sapium sebiferum.*

Habitat.—Taihoku, Shinten, Shirin, Suisha, Kagi.

Hitherto recorded only from Ceylon and India.

The Formosan specimens differ from the original description in the number of the stigmatic spines. They are variable from three to six, but usually four or five, in my specimens, though three according to Green.

This species is very common in Formosa and its habitat is always inclosed in the nest of *Cremastogaster rogenhoferi* (Formicidæ), never having been found outside of the nest of this ant, and sometimes occurs in abundance, causing serious damage to the host plant. Mr. Green has kindly compared the Formosan specimens with his material from Ceylon.

EUCALYMNATUS TESSELLATUS Signoret.

Hosts.—*Aglaia formosana, Calophyllum inophyllum, Cinnamomum* sp., *Euphoria longana, Heritiera littoralis, Palaquium formosanum.*

Habitat.—Taihoku, Kagi, Shinkwa.

Hitherto unrecorded from Formosa. The Formosan speciments are tessellated all over the dorsum, with 8-jointed antennæ. This species is very common in Kagi, but is rare in Taihoku.

PARALECANIUM EXPANSUM Green.

Lecanium expansum GREEN, Ind. Mus. Not. IV 1 (1896) 9.

Lecanium (Paralecanium) expansum GREEN, Cocc. Ceylon (1904) 235.

Hosts.—Ficus retusa, Machilus sp.

Habitat.—Taihoku, Shirin.

Hitherto unrecorded from Formosa. This species is very rare, occurring in very small numbers near Taihoku. *Paralecanium expansum* var. *quadratum* Green and other varieties have never been discovered in Formosa.

PULVINARIA PSIDII Maskell.

Hosts.—Artocarpus integrifolia, Chrysophyllum cainito, Coffea arabica, Euphoria longana, Gardenia florida, Mangifera indica, Psidium guyava, Psychotria elliptica.

Habitat.—Hokuto, Taihoku, Kagi.

This species is common in any season, occurring in abundance, and the foliage of the plants infested by this pest are black from a fungus growing in the honey dew. Maskell[5] recorded this species from *Citrus* in Formosa, but I have never collected it on *Citrus* in Formosa.

PULVINARIA POLYGONATA Cockerell.

Pulvinaria polygonata COCKERELL, Proc. Davenport Acad. Sci. 10 (1905) 131; MORRISON, Philip. Journ. Sci. 17 (1920) 184.

Pulvinaria cellulosa GREEN, Cocc. Ceylon (1909) 262.

Orthezia insignis SHIRAKI (nec Dougl.), Agr. Expt. St. Formosa, Spec. Rept. 8 (1913) 104; NITOBE, Rept. Stud. Citrus Ins. Formosa (1916) 44.

Pulvinaria aurantii MAKE (in part) (nec Ckll.), Forest Expt. St. Formosa, Spec. Rept. 1 (1915) 24; NITOBE, Rept. Stud. Citrus Ins. Formosa (1916) 51.

Hosts.—Citrus spp., *Murraya exotica.*

Habitat.—Taihoku, Shinchiku, Kagi.

The specimens identified as *Orthezia insignis* Dougl. or *Pulvinaria aurantii* Ckll. by Shiraki, Maki, or Nitobe proved to be *Pulvinaria polygonata* Ckll. This species sometimes occurs in large numbers on *Citrus* in the island. The immature forms on *Murraya exotica* are sometimes protected by *Cremastogaster rogenhoferi* (Formicidæ), some specimens of which have been compared by Mr. Green with his specimens from Ceylon. According to Morrison *Pulvinaria cellulosa* Green is a synonym of this species.

PULVINARIA THESPESIAE Green.

Pulvinaria thespesiae GREEN, Cocc. Ceylon (1909) 259; MORRISON, Philip. Journ. Sci. 17 (1920) 183.

[5] Ent. Mth. Mag. II 8: 243.

Host.—*Morus acidosa.*

Habitat.—Hakumo.

Hitherto unrecorded from Formosa. I observed this species in abundance on a *Morus* in September, 1926. These specimens agree exactly with Green's description and figures.

CEROPLASTES FLORIDENSIS Comstock.

Ceroplastes floridensis Comstock, KUWANA, Dept. Agr. Comm., Imp. Plant Quar. St., Bull. 3 (1923) 34.

Hosts.—*Carissa carandas, Citrus* sp., *Machilus* sp., *Maesa sinensis, Poncirus trifoliata, Psidium guyava, Schima confertiflora, Thea chinensis.*

Habitat.—Taihoku, Shimpo, Tsusho, Jukirin.

In Formosa this species is rather common, occurring, however, in very small numbers and is not a serious pest.

CEROPLASTES CERIFERUS And.

Ceroplastes ceriferus And., KUWANA, Dept. Agr. Comm., Imp. Plant Quar. St., Bull. 3 (1923) 43.

Hosts.—*Artemisia capillaris, Citrus* spp., *Melastoma candidum, Morus alba, Polygonum* sp., *Pometia pinnata, Rhodomyrtus tomentosa, Thea chinensis, Pygeum preslii.*

Habitat.—Taihoku, Kinpori, Sozan, Kagi, Botel Tobago.

This species is rather common, but is not abundant.

CEROPLASTES RUBENS Maskell.

Ceroplastes rubens Maskell, KUWANA, Dept. Agr. Comm., Imp. Plant Quar. St., Bull. 3 (1923) 18.

Host.—*Citrus* sp.

Habitat.—Taihoku, Heito, Shimpo, Shinten.

In Formosa this species is rare, occurring usually in very small numbers and is not of economic importance, though it is very injurious to *Citrus* in Japan.

CEROPLASTODES CHITON Green.

Ceroplastodes chiton GREEN, Cocc. Ceylon 4 (1909) 287.

Host.—*Ficus retusa,* attacking the air roots.

Habitat.—Keelung, Tansui, Taihoku.

Hitherto unrecorded from Formosa. Very common, sometimes occurring in abundance. Some of my specimens have been examined by Mr. Green.

LECANOPSIS SACCHARI sp. nov. Plate 1, fig. 5.

Adult female.—Dirty yellowish brown to blackish brown in specimens preserved in alcohol, surrounded and partially cov-

ered with a white felted test as in *Lecanopsis ceylanica* Green. Body ovate, narrower in front, strongly convex on the dorsum, with about four transverse shallow furrows on the dorsum. Antennæ short, stout, 6-jointed, almost as long as the tibia and tarsus taken together, with a few moderate setæ; the second, fourth, fifth, and sixth joints each almost as long as wide; the third cylindrical, stouter than the tibia, with a faint trace of division near the base; the sixth with some longer setæ; the relative length of joints about as follows: I, 10; II, 9; III, 19; IV, 5; V, 5; VI, 5. Spiracles equal in size and shape, with many pores on the side of orifice. Legs slender, with a few setæ, lacking pores; trochanters with a very long seta near the tip; femora almost as long as the tibia; tibiæ and tarsi usually fused together, sometimes with a trace of division; hind tibiæ almost three times as long as the tarsus; tarsal digitules long, slender, knobbed; claws without denticle, with two stout distinctly capitate hairs. Anal plates rounded on the outer edge and at the apex, not incurved at the apex, with five setæ on the apical portion, the base slightly longer than the outer edge. Anal ring with eight long setæ. Margin of the body with some long setæ of various length not arranged in a single row, numerous on the posterior portion, the longer ones almost as long as the third antennal joint. Anal lobes with several stouter setæ on the distal portion, of which one is longer, longer than the third antennal joint and about as long as the seta of the anal ring. Stigmatic clefts not developed; two stigmatic spines, widely separated, conical, about twice or thrice as long as wide, acuminate, not curved, shorter than the marginal seta. Body with many small circular multilocular pores and numerous tubular ducts scattered over the body; tubular ducts long, very abundant on the side and anal lobes.

Length of body, about 3.5 to 4.5 millimeters; antenna, about 0.25; hind tibiotarsus, about 0.25.

Hosts.—*Saccharum officinarum, Miscanthus* sp., a plant of the Gramineæ.

Habitat.—Kori, Taichu.

Some adult females and nymphs attached to the roots were collected by Mr. M. Yanagihara in May and October. This species is closely allied to *Lecanopsis ceylanica* Green,[6] but is distinguishable from it by the not incurved anal plates.

[6] Journ. Bombay Nat. Hist. Soc. 28: 1026.

The body is variable in length and is more heavily chitinized in the old females and the antennæ are sometimes 7-jointed. The antennæ of the larvæ are 6-jointed, with a quite long seta on the last joint and the tibiæ and tarsi are fused together as in the adult female.

TACHARDIINÆ

TACHARDINA THEAE Green and Mann.

Tachardina decorella var. *theae* GREEN and MANN, Mem. Dept. Agr. Ind., Ent. Ser. I 5 (1907) 348; II 2 (1908) 28.
Tachardina decorella FERRIS, Bull. Ent. Res. 12 (1921) 212.
Tachardina theae CHAMBERLIN, Bull. Ent. Res. 14 (1923) 210.
Kermes sp. MAKI, Forest Expt. St. Formosa, Spec. Rept. 1 (1915) 30.

Hosts.—Ardisia sieboldi, Ficus retusa, Machilus sp., *Michelia compressa, M. fuscata, M. longifolia, Myrica rubra, Thea chinensis, Rhodomyrtus tomentosa.*

Habitat.—Taihoku, Heitin, Kagi.

This species is fairly common in any season in Taihoku, occurring in abundance. Some specimens on *Myrica rubra* and *Michelia longifolia* have been examined by Dr. J. C. Chamberlin.

LACCIFER sp.

Tachardia sp. CHAMBERLIN, Bull. Ent. Res. 14 (1923) 173.
Laccifer sp. CHAMBERLIN, Bull. Ent. Res. 16 (1925) 39.

Host.—Citrus sp.

Habitat.—Heito (formerly Ako).

Chamberlin described the immature stage of this species from Formosa. A species of this genus collected by me on *Calliandra haematocephala, Averrhoa carambola, Ficus wightiana,* and *Machilus* sp. at Kagi, Formosa, may belong to this species.

ILLUSTRATIONS

PLATE 1

FIG. 1. *Pseudococcus saccharicola* sp. nov., adult female; *a*, outline of body; *b*, antenna; *c*, hind tibia and tarsus.

2. *Trionymus miscanthi* sp. nov., adult female; *a*, antenna; *b*, hind leg; *c*, posterior spiracle and pores; *d*, last cerarus and apical seta.

3. *Mizococcus sacchari* sp. nov., adult female; *a*, dorsal view; *b*, hind leg; *c*, antenna; *d*, pore; *e*, beak; *f*, hind spiracle; *g*, last cerarus; *h*, apical part of abdomen, showing the positions of anal ring, cerarii, and apical setæ.

4. *Asterolecanium corallinus* sp. nov., adult female; *a*, marginal pores; *b*, duct.

5. *Lecanopsis sacchari* sp. nov., adult female; *a*, anal plates; *b*, stigmatic spines; *c*, two types of multilocular pores; *d*, ducts.

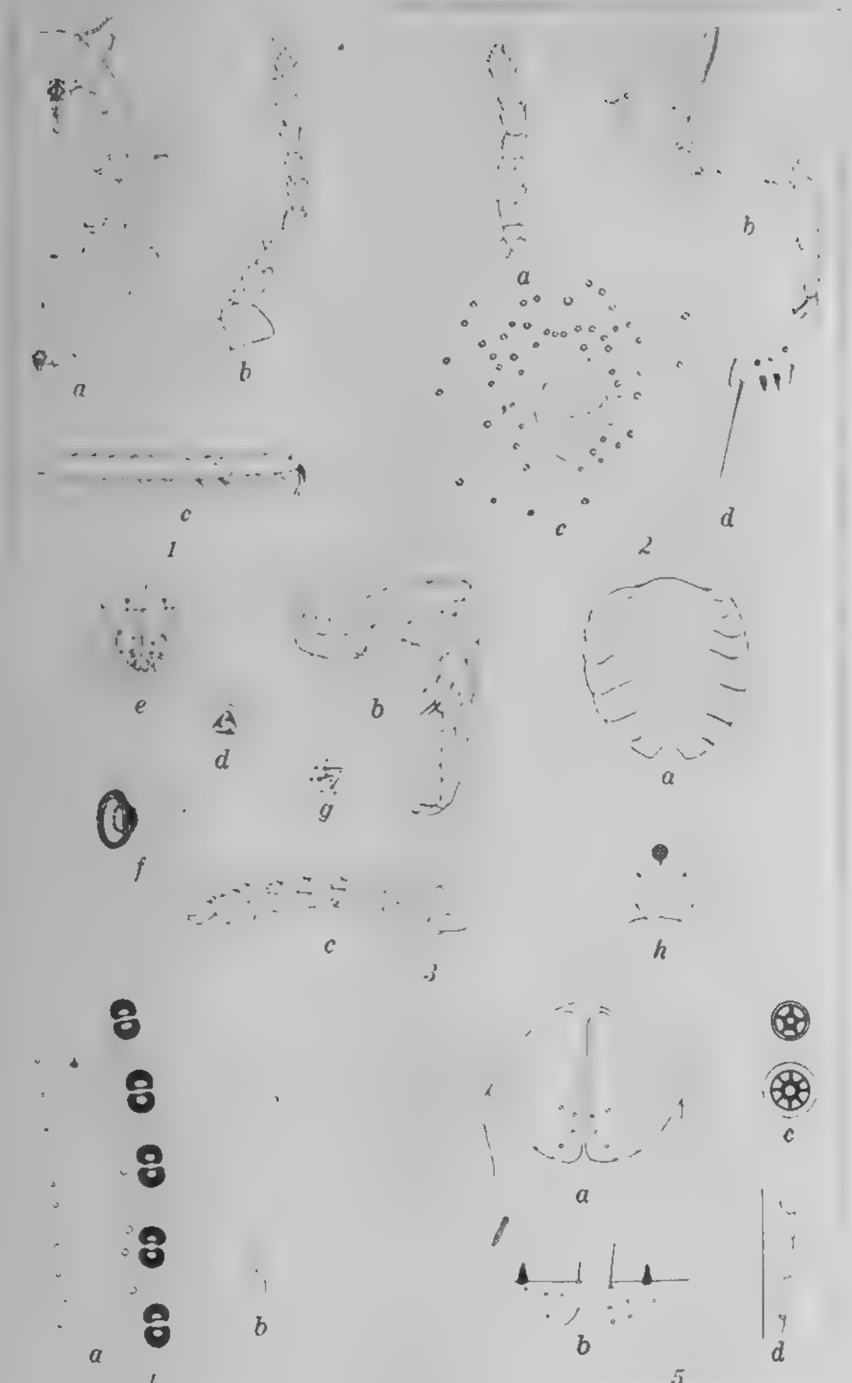

PLATE 1.

TREMATODE PARASITES OF PHILIPPINE VERTEBRATES

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FIVE PLATES

The trematodes of Philippine vertebrates, aside from those infesting man and the domesticated animals, are practically unknown. The parasites dealt with in this paper were collected from representative vertebrate hosts, which, with the exception of a species of bird caught in Cainta, Rizal Province, Luzon, were obtained from or near Los Baños, Laguna Province, Luzon, Philippine Islands. For convenience, they are arranged below according to their hosts.

FISH TREMATODES [1]

OPECOELUS MINIMUS sp. nov., Plate 1, figs. 1 and 2.

This is one of those rare trematodes, in which the intestinal branches do not end blindly in the body parenchyma but open outside through a ventrally located anus. It bears a close resemblance to *Opecoelus lobatus* Ozaki, 1925, but it may be distinguished from that species by the more posterior location of its acetabulum, the extent of its vitellaria, and the close approximation of its testes and ovary.

Description.—Body from 1.13 millimeters in length by 0.27 millimeter in maximum width across acetabulum to 2.09 by 0.50; somewhat spindle-shaped, rounded posteriorly and tapering anteriorly from level of acetabulum. Cuticle smooth. Oral sucker subterminal, moderately developed, circular in outline, 0.10 to 0.15 millimeter in transverse diameter. Acetabulum better developed and larger than oral sucker, 0.19 to 0.27 millimeter across, located between anterior and middle thirds of body length.

[1] For the determination of the vertebrate hosts mentioned in this paper, I am gratefully indebted to Mr. R. C. McGregor, of the Philippine Bureau of Science (birds), and to Dr. D. Villadolid and Mr. C. Manuel, of the College of Agriculture, University of the Philippines (fishes, frogs, and bats).

Mouth ventro-subterminal; prepharynx present, 0.023 millimeter long; pharynx well developed, 0.70 to 0.10 millimeter across; œsophagus 0.17 to 0.23 millimeter long, bifurcating at level about midway between pharynx and acetabulum. Intestinal cæca unite at level about midway between posterior testis and posterior end of body, forming a narrow common canal which leads outside through a ventral anal opening near posterior end of body. Genital pore conspicuous, located to one side of median line at level of œsophageal bifurcation.

Testes intercæcal, globular or slightly oval, 0.10 to 0.23 millimeter across, one immediately behind the other in fourth fifth of body length. Vasa efferentia short, terminating at about middle level of acetabulum. Cirrus pouch thin-walled, elongated, dilated at both extremities when extended and bottle-shaped when moderately contracted; 0.35 to 0.41 millimeter in length by 0.04 to 0.06 millimeter in maximum width; located to one side of median line, beside, and anterior of, acetabulum; incloses entire length of seminal vesicle, pars prostatica, and inconspicuous cirrus.

Ovary elliptical, 0.07 to 0.09 millimeter across, median, pretesticular, either in contact with, or separated by a very narrow space from, first testis. Shell gland diffuse, in front of ovary; receptaculum seminis and Laurer's canal not seen. Uterus poorly developed, containing only very few eggs, lying between ovary and acetabulum. Vagina leads to left side of genital opening. Vitellaria in distinct follicles on both sides of body, extending from level of acetabulum or even anterior of that level to posterior end of body; they overlap intestinal cæca and behind second testis they coalesce. Vitelline ducts prominent, emptying into oval vitelline reservoir situated anterodorsally of ovary. Eggs oval, operculated, yellowish to yellowish brown in color, 0.078 to 0.080 millimeter by 0.056 millimeter in size.

The excretory bladder, which opens outside through a median posterodorsal excretory pore, is Y- or T-shaped and reaches anteriorly to anterior level of ovary (Plate 1, fig. 2). Each horn of the bladder is continued as a main lateral collecting tube, which soon divides into anterior and posterior collecting tubules. Each collecting tubule in turn is converted into four capillary branches, each of which terminates into a flame cell. The excretory formula is, therefore, $2 \times 8 \times 1 = 16$ flame cells in all.

Hosts.—*Glossogobius giurus* (Hamilton-Buchanan), *G. biocellatus* Cuvier and Valenciennes, and *Pristipoma hasta* Bloch.

Location.—Intestine.

Locality.—Laguna de Bay, Los Baños, Laguna Province, Luzon.

METADENA MICROVATA sp. nov. Plate 1, fig. 3.

There are in the available literature three genera of fish trematodes, namely, *Metadena* Linton, 1910, *Stepoda* Linton, 1910, and *Exorchis* Kobayashi, 1921, with the members of which the small distome under consideration presents certain affinities. It has been decided to place it in *Metadena* in preference to one of the other genera because, in the first place, it does not conform to the important diagnostic feature of *Exorchis*, which is the extracæcal position of the testes; and, in the second place, the description of *Stepoda*, as Linton himself admits, is so incomplete that it is difficult to recognize the genus.

Description.—Body small, oval, from 0.70 millimeter in length by 0.32 millimeter in maximum width across middle of body to 0.90 by 0.44. Cuticle covered with minute posteriorly directed spines. Oral sucker moderately developed, circular in outline, 0.10 to 0.14 millimeter across. Acetabulum weak, very much smaller than oral sucker, 0.03 to 0.05 millimeter across, situated in posterior portion of anterior third of body length. Mouth subterminal; pharynx immediately behind oral sucker, 0.06 to 0.08 millimeter in transverse diameter; œsophagus 0.05 to 0.07 millimeter long, its point of bifurcation at level of acetabulum. Intestinal cæca moderately dilated, reaching as far as posterior level of testes. Genital pore median, inconspicuous, immediately in front of acetabulum.

Testes slightly oval, 0.07 to 0.09 millimeter across, intercæcal, symmetrically placed on both sides of median line, at or immediately behind equator of body. Seminal vesicle slightly coiled, voluminous, in front of ovary and testes. Cirrus pouch apparently absent.

Ovary median or nearly median in position, distinctly trilobed, between seminal vesicle and testes. Uterus moderately developed, postovarian, posttesticular, reaching to posterior end of body. Vitellaria in distinct follicles, extending from level of genital pore to anterior border of testes. Eggs yellowish brown in color, oval, operculated, from 0.018 millimeter by 0.011 millimeter to 0.022 by 0.012 in size.

Excretory pore terminal, its position marked by an indentation at posterior end of body. Excretory bladder V-shaped, reaching anteriorly up to posterior margin of testes.

Hosts.—*Glossogobius giurus* (Hamilton-Buchanan), *G. biocellatus* Cuvier and Valenciennes, and *Pristipoma hasta* Bloch.

Location.—Intestine.

Locality.—Laguna de Bay, Los Baños, Laguna Province, Luzon.

AZYGIA PRISTIPOMAI sp. nov. Plate 1, fig. 4.

The general characters of this fluke place it in the genus *Hassallius* Goldberger, 1911. It is referred, however, to *Azygia* Looss, 1899, following the opinion of Ward (1920), who considers the two generic names as synonymous. It is nearly related to *Azygia* (*Hassallius*) *hassalli* Goldberger, 1911, but it may be distinguished at once from the latter species by the position of its vitellaria which do not pass posteriorly beyond the level of the second testis.

Description.—Body from 1.93 millimeters in length by 0.86 millimeter in maximum width at or near equator of body to 3.20 by 1.00; plump, short to long oval in shape, rounded at both extremities. Cuticle smooth. Oral sucker ventro-subterminal, large and muscular, almost spherical, 0.34 to 0.45 millimeter across. Acetabulum spherical, well developed but smaller than oral sucker, 0.31 to 0.38 millimeter in transverse diameter, situated between anterior and middle thirds of body length. Mouth ventroterminal; prepharynx absent; pharynx well developed, 0.16 to 0.18 millimeter across; œsophagus absent. Intestinal cæca at first make a straight transverse line behind pharynx and then curve posteriorly, each describing a right angle, and pass in moderate zigzags to posterior end of body. Genital pore immediately preacetabular, median.

Testes entire, oval, from 0.20 millimeter by 0.11 millimeter to 0.25 by 0.13 in size; intercæcal but slightly overlapped by corresponding intestine, asymmetrical, at middle of last fourth of body length, with left testis usually more advanced anteriorly than right testis. Cirrus sac circular, thin-walled, 0.23 to 0.25 millimeter in diameter; incloses slightly coiled and dilated seminal vesicle, pars prostatica, and ejaculatory duct.

Ovary entire, transversely oval, intertesticular, on a level with left testis and slightly to one side of median line; 0.18 millimeter by 0.12 millimeter in size. Shell gland appears compact, at anterior inner border of ovary. Laurer's canal and receptaculum seminis not seen. Uterus in transverse coils, occupying nearly all the space bounded by acetabulum, intestinal cæca, ovary, and testes. Vitellaria in distinct rounded follicles, extra-

cæcal, extending from immediately behind posterior level of acetabulum to testes. Eggs yellowish in color, oval, operculated, from 0.066 millimeter by 0.044 millimeter to 0.068 by 0.040 in size.

Excretory pore caudoterminal; excretory bladder moderately dilated, reaching anteriorly up to or beyond region of testes, at which point it bifurcates. The arrangement of the excretory tubes could not be made out.

Host.—*Pristipoma hasta* Bloch.

Location.—Intestine.

Locality.—Laguna de Bay, Los Baños, Laguna Province, Luzon.

AMPHIBIAN TREMATODES

GLYPTELMINS STAFFORDI sp. nov. Plate 2, fig. 1.

This trematode differs from *Glyptelmins quieta* Stafford, 1900, the type species of the genus, as well as from three Brazilian species reported by Travassos (1924) in the extent of its vitellaria, in the arrangement of the testes and ovary, and in the size of the eggs. It is named after Dr. Joseph Stafford, American helminthologist.

Description.—Body ovoid or elongated, depending upon the state of preservation, with rounded extremities, from 2.09 millimeters in length by 0.63 millimeter in maximum width across testes to 4.15 by 1.01. Cuticle covered with conspicuous spines which become scarce from middle of body length to posterior end. Oral sucker ventroterminal, moderately developed, 0.19 to 0.29 millimeter across. Acetabulum smaller than oral sucker, 0.15 to 0.18 millimeter across, between anterior and middle thirds of body length or immediately anterior of that level. A very short prepharynx separates globular pharynx, 0.10 to 0.15 millimeter across, from oral sucker; œsophagus 0.04 millimeter long; intestinal branches nearly reach posterior end of body. Genital pore immediately in front of acetabulum, median in position or at most slightly inclined towards one side of median line.

Testes rounded, 0.18 to 0.22 millimeter across, nearly symmetrical with left testis usually slightly more advanced anteriorly than its fellow; postacetabular, in second fourth of body length. Cirrus sac from 0.26 millimeter by 0.06 millimeter to 0.33 by 0.09 in size, obliquely placed, partly overlapping acetabulum; incloses coiled seminal vesicle, short pars prostatica, and protrusible cirrus.

Ovary rounded, 0.13 to 0.18 millimeter across; at left of, at the same plane as, and partly overlapping, acetabulum. Shell gland diffuse, median, between testes and acetabulum. Receptaculum seminis and Laurer's canal not seen. Uterus with numerous transverse coils, between testes and posterior end of body, intercæcal although overlapping intestinal branches at certain places. Vitellaria in distinct follicles, not arranged into groups; extracæcal, oftentimes asymmetrical: those on left side of body fewer in number and more advanced anteriorly, extending from level of genital pore to anterior portion of last third of body length; those on right side more numerous and extending from middle level of acetabulum to anterior portion of last fourth of body length. Eggs oval, operculated, yellowish brown to brown in color, from 0.031 millimeter by 0.018 millimeter to 0.033 by 0.015 in size.

The excretory bladder, which opens outside through a median posterodorsal pore, is Y-shaped and located behind the blind ends of the intestinal branches. Each horn of the bladder is continued anteriorly as a narrow collecting tubule to the lateral aspect of the pharynx. I was unable to determine from the study of living specimens even the approximate number of capillary branches arising from the collecting tubules and I succeeded in finding only two pairs of flame cells located on the sides of the pharynx.

Host.—*Rana vittigera* Wiegmann.

Location.—Intestine.

Localities.—Los Baños and Bay, Laguna Province, Luzon.

PLEUROGENES TAYLORI sp. nov. Plate 2, figs. 2 and 3.

This trematode is named for Mr. E. H. Taylor, authority on Philippine amphibians and reptiles. According to the key of Kleine (1905) to the known species of the genus *Pleurogenes* Looss, 1896, it is closely allied to *P. gastroporus* Luehe in the apparent absence of an œsophagus, in the position of the genital pore beside the oral sucker, and in the ventral location of the excretory pore near the posterior end of the body. It differs, however, from that species in the position of its testes, which lie anterior to the terminations of the intestinal branches.

Description.—Body oval, rounded at both extremities with posterior end broader; from 0.60 millimeter in length by 0.38 millimeter in maximum width across acetabulum or a little posterior of that level to 0.80 by 0.50. Cuticle armed with

conspicuous posteriorly directed spines arranged in transverse rows. Oral sucker circular, ventro-subterminal, 0.13 to 0.16 millimeter across. Acetabulum also circular, a trifle smaller than oral sucker, 0.12 to 0.15 millimeter across, located in middle of body length or a little posterior of that level. Prepharynx absent; pharynx well developed, 0.06 to 0.08 millimeter across; œsophagus absent. Intestinal branches moderately dilated but hidden by genital organs in ventral view; they end in front of middle level of acetabulum. Genital pore sinistral, beside oral sucker.

Testes large, round to oval, from 0.11 millimeter by 0.09 millimeter to 0.17 by 0.13 in size (compressed specimens); located symmetrically immediately in front of middle level of acetabulum. Cirrus sac bottle- or Indian-club-shaped, from 0.21 millimeter by 0.09 millimeter to 0.39 by 0.13 in size; when not retracted, it extends obliquely from median line in front of acetabulum to genital pore; it incloses coiled vesicula seminalis, pars prostatica, and protrusible cirrus.

Ovary rounded or slightly oval, 0.07 to 0.10 millimeter in transverse diameter, dextral, located anteromesially of, and overlapped by, right testis. Receptaculum seminis elongated, beside acetabulum, on the same side as ovary; Laurer's canal present. Uterus well developed, occupying most of space behind acetabulum and testes. Vagina opens behind cirrus. Vitellaria composed of 7 to 9 large, round to oval follicles in anterior part of body in front of testes and ovary. Vitelline follicles not symmetrically placed, those on left side being displaced internally towards median line by cirrus sac. Vitelline reservoir between receptaculum seminis and acetabulum. Eggs elongated, operculated, yellowish to dark brown in color, 0.031 millimeter by 0.015 millimeter in size.

The excretory bladder, which opens outside through a median posteroventral pore, is V-shaped. From each horn of the bladder an anterior and a posterior collecting tubule are given off. As shown in Plate 2, fig. 3, the anterior and posterior collecting tubules each ends in five capillary branches and each capillary is connected to a flame cell. The excretory formula is, therefore, $2 \times 10 \times 1 = 20$ flame cells in all.

Host.—*Rana vittigera* Wiegmann.

Location.—Intestine.

Localities.—Los Baños and Bay, Laguna Province, Luzon.

REPTILIAN TREMATODES

PARADISTOMUM MAGNUM sp. nov. Plate 3, fig. 1.

In specimens killed in hot corrossive sublimate-acetic acid solution without pressure, this fluke conforms to the diagnostic characters of the genus; namely, the oval outline and the symmetrical position of the testes. When fixed, however, under the pressure of a cover glass, it assumes a form somewhat similar to that possessed by the members of the genus *Eurytrema;* that is, it becomes broader and longer and tapers towards both extremities.

This parasite is similar in many respects to the European form, *Paradistomum mutabile* (Molin), but it differs from it in two important characters. In the first place, the ovary of the European species, according to Luehe (1900) and to Rizzo (1902), is spherical or globular, that of the Philippine form being distinctly lobed. In the second place, the eggs of *P. mutabile* are from 0.040 to 0.050 millimeter by 0.025 to 0.026 millimeter in size, those of the present species being from 0.035 by 0.022 to 0.038 by 0.024 in size.

Description.—Body in specimens killed without pressure, oval in general shape, thick, broadly rounded posteriorly, narrower anteriorly, from 1.91 millimeters in length by 1.40 millimeters in maximum width to 2.60 by 1.63; in pressed specimens the body is broad, attenuated towards both ends, from 3.85 by 2.06 to 4.50 by 2.18 in measurements. Cuticle smooth. Oral sucker subterminal, poorly to moderately developed, 0.36 to 0.38 millimeter across. Acetabulum circular in outline, weak, 0.43 to 0.45 millimeter in diameter, situated between anterior and middle thirds of body length. Mouth subterminal; prepharynx absent; pharynx 0.13 to 0.15 millimeter across; œsophagus narrow, 0.19 millimeter long. Intestinal cæca unusually wide in diameter, thin-walled, filled with yellowish to brownish fæcal material; extend to about 0.7 millimeter from posterior end of body. Genital pore preacetabular, median, immediately in front of point of origin of intestinal cæca.

Testes relatively small, oval or pyriform in shape, from 0.23 millimeter by 0.17 millimeter to 0.32 by 0.20 in size; symmetrical, immediately behind posterior level of acetabulum. Seminal vesicle poorly developed; inclosed in elongated cirrus sac, 0.40 millimeter by 0.06 millimeter in size.

Ovary distinctly 3-lobed, 0.13 millimeter by 0.20 millimeter in size, lying to one side of median line immediately behind

posterior level of testes. Shell gland distinct, median, slightly lobed. Receptaculum seminis and Laurer's canal present. Uterus in loose irregular coils, mostly posttesticular and postovarian, overlapping intestinal branches. Vitellaria in small, round to oval follicles, extracæcal, occupying middle third of body length. Eggs oval, operculated, yellowish or dark brown in color, 0.035 millimeter by 0.022 millimeter to 0.038 by 0.024 in size.

The excretory bladder, which opens outside through a median posterodorsal pore, is voluminous. I was unable to follow its course anteriorly.

Host.—*Hemidactylus frenatus* Duméril and Bibron.

Location.—Gall bladder.

Locality.—Los Baños, Laguna Province, Luzon.

POSTORCHIGENES OVATUS g. et sp. nov. Plate 2, fig. 4.

This trematode presents affinities with the members of the subfamily Pleurogenetinæ Looss, 1899, owing to the arrangement of the genital glands and the location of the genital pore away from the median line. The vitellaria extend, as in the genus *Loxogenes* Stafford, 1905, across the entire body from the pharynx to the acetabulum. In other important respects, however, the species does not fit into any of the genera listed in the subfamily, for which reason a new genus is proposed for its reception.

Generic diagnosis.—Pleurogenetinæ: small distomes with thick, oval or pear-shaped body and with spinous cuticle. Suckers small, poorly developed; acetabulum smaller than oral sucker, in front of equator of body. Pharynx present; œsophagus very short; intestinal branches reach to and beyond center of body. Ovary round to oval, on right side of acetabulum. Bulk of vitellaria dorsal; extend across entire body from pharynx to acetabulum. Laurer's canal and receptaculum seminis present; shell gland diffuse. Uterus postacetabular, postovarian, posttesticular. Testes entire, postacetabular, postovarian, nearly symmetrical on both sides of body. Cirrus sac on left side of acetabulum opposite ovary. Genital pore ventral, sinistral, about midway between center and margin of body at level of acetabulum. Ova small, numerous.

Type species, *Postorchigenes ovatus* sp. nov.

Description of type species.—Body oval or pear-shaped, thick, with rounded ends, from 1.55 millimeters in length by 0.88 millimeter in maximum width across posterior third of body

length to 1.66 by 1.10. Cuticle with transverse rows of posteriorly directed spines. Oral sucker subterminal, weak, oval in outline, from 0.15 millimeter by 0.12 millimeter to 0.20 by 0.15 in size. Acetabulum smaller than oral sucker, from 0.11 millimeter by 0.09 millimeter to 0.17 by 0.13 in size, between anterior and middle third of body length. Pharynx weak, 0.06 to 0.07 millimeter across; œsophagus very short, almost nil; intestinal branches slightly wavy in outline, reach to and beyond center of body. Genital pore ventral, sinistral, at posterior level of acetabulum, about midway between center and margin of body.

Testes large, oval, postacetabular, from 0.29 millimeter by 0.24 millimeter to 0.37 by 0.27 in size, nearly symmetrical (left testis usually slightly more advanced anteriorly than its fellow), at or near middle of body length; right testis not as conspicuously seen as left testis in ventral view, being overlapped by uterine coils. Cirrus sac slightly oval, 0.18 to 0.26 millimeter across, sinistral, lying beside, and partly overlapped by, acetabulum; incloses coiled seminal vesicle, pars prostatica, and long muscular cirrus.

Ovary oval, entire, from 0.22 millimeter by 0.16 millimeter to 0.26 by 0.23 in size, dextral, in the same plane as cirrus sac and also slightly overlapped by acetabulum. Receptaculum seminis small, pyriform, postovarian; Laurer's canal present; shell gland diffuse. Uterus profusely developed, occupies nearly all of space in body behind ovary, acetabulum, and left testis. Vitellaria in distinct follicles, the bulk of which occupy a dorsal position across body from pharynx to acetabulum. Eggs oval, operculated, yellowish to dark brown in color, measuring 0.024 millimeter by 0.012 millimeter.

Excretory pore median, posteroventral, its position often marked by an indentation. Excretory bladder V-shaped, its lateral branches being inflated and terminating behind testes.

Host.—*Hemidactylus frenatus* Duméril and Bibron.

Location.—Intestine.

Locality.—Los Baños, Laguna Province, Luzon.

AVIAN TREMATODES

METORCHIS CAINTAENSIS sp. nov. Plate 3, figs. 2 and 3.

This parasite differs from the already known members of the genus *Metorchis* in the position of the vitellaria, which extend from immediately behind the level of the acetabulum to the posterior end of the body. In the other members of the genus the

vitellaria do not reach posteriorly beyond the level of the first testis. For this reason, if one were to follow the example of Barker (1911), who divided the related genus *Opisthorchis* (Blanchard) into *Opisthorchis* s. str. and *Amphimerus* on the basis of the extent of the vitellaria, it would be justifiable to erect a new genus for the species under discussion. For the present, however, it seems best to refer it to *Metorchis*.

Description.—Body flat, elongated, tapering anteriorly, from 0.94 millimeter in length by 0.46 millimeter in maximum width to 2.00 by 0.81. Cuticle armed with prominent spines. Oral sucker spherical, from 0.08 to 0.12 millimeter in diameter. Acetabulum weak, from 0.06 to 0.08 millimeter across, situated in very close proximity to oral sucker, sometimes almost at the same level as pharynx. Mouth subterminal; pharynx inconspicuous, 0.05 to 0.08 millimeter in transverse diameter; œsophagus very short or absent; intestinal branches extend to near posterior end of body. Genital pore median, immediately in front of acetabulum.

Testes large, slightly indented so that there are recognizable five lobes in the anterior, and four lobes in the posterior testis; they are placed slightly obliquely one behind the other, filling up most of the space between intestinal cæca and vitelline glands in posterior half of body length. Seminal vesicle prominent and much convoluted.

Ovary rounded, 0.09 to 0.13 millimeter across, partly hidden by uterine coils, anterior of first testis, towards right side of median line. Receptaculum seminis on the same plane as ovary, as large as, and on the left side of, that organ. Laurer's canal present; shell gland diffuse. Uterus conspicuous, occupying most of the space bounded by anterior testis, intestinal cæca and acetabulum in anterior half of body length. Vagina opens on left side of ejaculatory duct. Vitellaria profuse, extracæcal, extending from behind level of acetabulum to posterior end of body, from which point they curve mesoanteriorly to posterior border of second testis. Eggs oval, operculated, yellowish to yellowish brown in color, 0.036 millimeter by 0.021 millimeter in size.

Excretory bladder narrow, opens outside through genital pore at extreme posterior end of body.

Host.—*Hypotænidia philippensis.*

Location.—Intestine.

Locality.—Cainta, Rizal Province, Luzon.

LEUCOCHLORIDIUM DASYLOPHI sp. nov. Plate 4, figs. 1 and 2.

This interesting trematode was obtained in large numbers on two occasions from the cloaca of the rough-crested cuckoo, *Dasylophus superciliosus* (Cuvier). It apparently represents a new species, for it differs in several important respects from the *Leucochloridium* species described by Witenberg (1925) in his monograph on the trematode subfamily Harmostominæ, of which *Leucochloridium* is a member. From *L. insigne* (Looss, 1899) and *L. turanicum* (Soloviev, 1912) it can be recognized at once by the posterior extent of the vitellaria, which do not pass beyond the blind terminations of the intestinal branches. In the position of the vitelline glands and in the location of the acetabulum, it is similar to *L. macrostomum* (Rudolphi, 1802), but it may be separated from that and other related species by the distribution of its uterine coils which reach to the posterior end of the body, thus obscuring or totally hiding the presence of the cirrus sac.

Description.—Body elongated, with rounded extremities, thicker anteriorly than posteriorly, from 2.72 millimeters in length by 1.07 millimeters in maximum width across acetabulum to 3.30 by 1.10. Cuticle armed with delicate spines. Suckers very well developed: oral sucker ventro-subterminal, 0.50 to 0.57 millimeter across; acetabulum in equator of body, 0.70 to 0.75 millimeter across. Mouth ventroterminal; prepharynx absent; pharynx strong, 0.13 to 0.18 millimeter across; œsophagus absent. Intestinal cæca describe a graceful curve anterolaterally before passing posteriorly; they end slightly beyond posterior level of second testis. Genital pore median, dorsal, located at about 0.1 millimeter from posterior end of body.

Testes round, 0.18 to 0.31 millimeter in diameter, obliquely placed on each side of median line in middle of last third of body length; separated by a space equivalent to one-half of their diameters. Cirrus sac very small, oval, near posterior end of body, 0.090 millimeter by 0.072 millimeter in size.

Ovary round, 0.15 to 0.18 millimeter in diameter, to one side of median line in front of second testis. Shell gland diffuse, on posteromesial side of ovary. Receptaculum seminis not seen; Laurer's canal present, open on dorsal surface at about 0.5 millimeter from posterior end of body. Uterus very profuse, extending anteriorly to intestinal arches and posteriorly to near posterior end of body. Laterally the uterine coils overlap intestinal cæca, being bounded for the most part by vitelline glands. Vitellaria in distinct, oval or elongated follicles, extending from

level of pharynx to posterior level of anterior testis. Eggs oval, operculated, light to dark brown in color, 0.031 to 0.033 millimeter by 0.18 millimeter in size.

Host.—*Dasylophus superciliosus* (Cuvier).

Location.—Cloaca.

Locality.—Los Baños, Laguna Province, Luzon.

Among the mature forms of *Leucochloridium dasylophi* is a single specimen, which is believed to represent the immature stage of this species in its final host. The body (Plate 5, fig. 2) is pyriform in shape, more rounded anteriorly than posteriorly, measuring 0.92 millimeter in length by 0.37 millimeter in maximum width across the acetabulum. It is thus very much smaller than the immature stage of *Leucochloridium problematicum* Magath, 1920. The cuticle is sparsely covered with delicate spines. The suckers are well developed: oral sucker cup-shaped, ventroterminal, 0.16 millimeter by 0.19 millimeter in size; acetabulum slightly oval, 0.23 by 0.20 in size, at equator of body. Mouth ventroterminal; prepharynx absent; pharynx 0.07 millimeter across; œsophagus absent. Intestinal cæca describe the same graceful curve at point of origin as in the mature form and zigzag moderately towards posterior end of body. Testes rounded, large, arranged obliquely in posterior third of body length. Ovary rounded, anterior of second testis, at about same level as first testis. Cirrus sac in the form of a faint oval structure in median line, posterior of blind ends of intestines. Vitelline glands in distinct follicles, ten to eleven in number; extracæcal, extending from behind level of pharynx to middle level of anterior testis.

HARMOSTOMUM sp. Plate 4, fig. 3.

Numerous immature specimens of a fluke were obtained from the cloaca of the rough-crested cuckoo in company with *Leucochloridium dasylophi*. They are believed to represent a species of *Harmostomum* due to the arrangement of the reproductive glands and to the position of the genital pore.

Description.—Body elongated, rounded at both extremities, 1.64 millimeters in length by 0.29 millimeter in maximum width across pharynx to 1.75 by 0.36. Cuticle armed with small spines. Oral sucker ventroterminal, oval in outline, 0.29 millimeter by 0.18 millimeter to 0.32 by 0.22 in size. Acetabulum slightly oval, 0.26 millimeter by 0.21 millimeter to 0.28 by 0.24 in size, located anterior to middle of body length. Pharynx globular, 0.11 to 0.13 millimeter across; œsophagus absent. Intestinal

cæca pass anterolaterally on both sides of pharynx, describe acute angles, and then pass in moderate zigzags to posterior end of body. Genital pore median, immediately in front of first testis.

Testes round to oval, 0.11 to 0.15 millimeter long by 0.09 to 0.10 millimeter wide, one behind the other in last fourth of body length. Cirrus sac pear-shaped, immediately in front of first testis.

Ovary oval, 0.08 to 0.09 millimeter by 0.06 to 0.07 millimeter in size, between, and slightly overlapped by, testes. Uterus represented by a narrow canal going from ovary towards acetabulum, from which point it doubles on itself and runs posteriorly towards genital pore. Vitellaria extracæcal, in groups of eight to nine minutely granular follicles, extending from immediately behind acetabulum to anterior or middle level of cirrus pouch.

Excretory bladder narrow, opens outside through a posteroterminal excretory pore.

Host.—*Dasylophus superciliosus.*

Location.—Cloaca.

Locality.—Los Baños, Laguna Province, Luzon.

STOMYLOTREMA ROTUNDA sp. nov. Plate 4, fig. 4.

Among the members of the genus *Stomylotrema* Looss, 1900, this parasite appears to be most similar to *S. bijugum* Braun, 1901, but it may be differentiated from the latter by the appearance and extent of its vitellaria and by the size of its eggs. In *S. bijugum* the vitelline follicles are in the form of a "3" or an "8" and extend posteriorly beyond the middle level of the acetabulum; in the present form the vitelline glands are irregularly shaped and do not reach beyond the middle level of the acetabulum. In *S. bujugum* the eggs are brown in color and measure 0.019 millimeter by 0.014 to 0.018 millimeter; in *S. rotunda* they are yellowish in color and measure 0.032 to 0.034 by 0.020.

Description.—Body round to oval, curved ventrally, with rounded extremities, from 1.32 millimeters in length by 0.70 millimeter in maximum width across testes or immediately posterior of that level to 1.64 by 0.96. Cuticle smooth. Suckers very strongly developed; oral sucker subterminal, 0.41 to 0.52 millimeter across; acetabulum posteroventral, immediately behind testes, 0.45 to 0.55 millimeter across. Pharynx immediately behind oral sucker, globular, 0.14 to 0.19 millimeter across; œsophagus absent; intestinal branches reach to posterior end of

body behind acetabulum. Genital pore lateral, dextral, in front of anterior level of pharynx.

Testes rounded or very slightly oval, 0.18 to 0.21 millimeter across, symmetrically placed immediately behind middle of body length. Cirrus sac slender, pointed at distal end, from 0.41 millimeter by 0.07 millimeter to 0.55 by 0.09 in size.

Ovary rounded, 0.13 to 0.15 millimeter across, to one side of median line opposite base of cirrus sac. (Another way of describing the location of the ovary is to state that it is between the pharynx and the left testis, a straight line drawn through the two organs touches the ovary.) Diffuse shell gland and vitelline reservoir near center of space bounded by testes, ovary, and cirrus sac. Uterine coils well distributed between different genital glands, crossing and hiding intestinal branches in several places and looped around acetabulum posteriorly. Vagina opens behind male organ into genital pore. Vitelline glands in irregularly shaped follicles, seven on right side and nine on left, not reaching posteriorly behind middle level of acetabulum. Eggs oval, operculated, yellowish in color, 0.032 to 0.034 millimeter by 0.020 millimeter in size.

Host.—*Hypotænidia philippensis* (Linnæus).

Location.—Intestine.

Locality.—Cainta, Rizal Province, Luzon.

MAMMALIAN TREMATODES

LECITHODENDRIUM OVIMAGNOSUM Bhalerao, 1926. Plate 5, fig. 1.

Specimens collected from the Philippine bat *Scutophilus temminckii* (Horsfield) bear such a very close resemblance to a species of fluke described from the Burmese bat *Nyctinomus plicatus*, by Bhalerao (1926), that I think they are of the same species in spite of apparent differences in total size, egg measurements, and size of ovary. The following description is based on Philippine material.

Description.—Body pyriform to oval, depending upon the state of preservation; usually broadly rounded posteriorly in specimens fixed without pressure in corrosive sublimate acetic acid solution and moderately attenuated anteriorly; from 0.36 millimeter in length by 0.26 millimeter in maximum width across acetabulum or immediately posterior of that level to 0.104 by 0.80. Cuticle unarmed. Oral sucker circular, 0.06 to 0.12 millimeter in transverse diameter. Acetabulum smaller than oral sucker, 0.05 to 0.10 millimeter across, located at or near equator

of body. Mouth subterminal; pharynx immediately behind oral sucker, 0.03 to 0.05 millimeter across; œsophagus absent; intestinal cæca very short, reaching posteriorly as far as anterior borders of testes. Genital pore median, about midway between pharynx and acetabulum.

Testes transversely oval, from 0.10 millimeter by 0.15 millimeter to 0.12 by 0.20 in size; symmetrically placed on both sides of acetabulum and on a level with that organ. Cirrus sac prominent, circular, 0.07 to 0.14 millimeter in diameter, situated between pharynx and acetabulum; incloses a much-coiled seminal vesicle, pars prostatica, and apparently nonprotrusible cirrus.

Ovary relatively large, 0.20 to 0.25 millimeter across, distinctly lobed, somewhat like an acanthus leaf in shape; lies between testes, inclined towards one side of median line. Shell gland diffuse, receptaculum seminis small, and Laurer's canal present. The latter structures and the vitelline reservoir are located posterior of the ovary. Uterus posttesticular, postacetabular. Vitellaria in distinct, few, but relatively large follicles, arranged symmetrically on both sides of pharynx anterior of testes. Eggs oval, operculated, yellowish brown in color, 0.026 millimeter by 0.014 millimeter in size.

Excretory bladder V-shaped, voluminous, opening outside through a median posterior excretory pore. Arms of bladder reach anteriorly to level of acetabulum.

Host.—*Scutophilus temminckii.*

Location.—Intestine.

Locality.—Los Baños, Laguna Province, Luzon.

LECITHODENDRIUM LUZONICUM sp. nov. Plate 5, figs. 2 and 3.

This species differs from *L. ovimagnosum* by its elongated shape and larger size, by its well-developed and cup-shaped oral sucker, and by its unlobed ovary. It seems not to fit into the key of *Lecithodendrium* species prepared by Bhalerao (1926), for which reason it is here considered as á new species.

Description.—Body elongated, from 1.10 millimeter in length by 0.44 millimeter in maximum width at, or immediately behind, acetabulum to 1.37 by 0.46. Cuticle unarmed. Oral sucker ventroterminal, well developed, measuring from 0.26 millimeter by 0.16 millimeter to 0.28 by 0.17. Acetabulum much smaller than oral sucker, circular in outline, 0.14 to 0.15 millimeter across, lying at about middle of body length or a little anterior of that level. Mouth ventroterminal; pharynx, 0.07 to 0.09 millimeter across, immediately follows oral sucker; œsophagus

absent; intestinal cæca short, with a posterolateral course, ending in front of testes. Genital pore median, between acetabulum and pharynx but closer to latter.

Testes round to oval, 0.10 to 0.12 millimeter across, symmetrically placed on each side of median line in front of acetabulum. Cirrus sac large, circular in outline, 0.13 to 0.16 millimeter across, pretesticular, preoverian, partly overlapping latter organs. Seminal vesicle much coiled, inclosed in cirrus sac.

Ovary round to oval, median, intertesticular, 0.07 to 0.08 millimeter across. Shell gland distinct, circular or oval in outline (Plate 7, fig. 2). Receptaculum seminis flasked-shaped; Laurer's canal dilated. Uterus postacetabular, posttesticular. Vitellaria in distinct follicles on each side of pharynx, reaching anteriorly as far as middle level of oral sucker and posteriorly to testes. Eggs oval, operculated, yellowish brown in color, 0.037 millimeter by 0.016 millimeter in size.

Excretory pore median, terminal. Excretory bladder roomy, V-shaped, reaching anteriorly as far as acetabulum.

Host.—*Scutophilus temminckii* (Horsfield).

Location.—Small intestine.

Locality.—Los Baños, Laguna Province, Luzon.

PLATYNOSOMUM PHILIPPINORUM sp. nov. Plate 5, fig. 4.

This distome presents two features that are unusual for a member of the subfamily Dicrocoellinæ; namely, its location in the small intestine of the host, the other members of the subfamily, with the exception of *Eurytrema ovis* Tubangui, 1925, inhabiting the gall bladder or pancreatic duct of their hosts; and the posession of a spinous cuticle, the cuticle of the known members of the subfamily, with the exception of *Dicrocoelium macaci* Kobayashi, 1921, being unarmed.

Description.—Body elongated or lancet-shaped, from 1.93 millimeters in length by 0.54 millimeter in maximum width at middle of body length or slightly anterior of that level to 2.27 by 0.56. Cuticle armed with small spines which become scarce from the middle of the body length to posterior end. Oral sucker subterminal, cup-shaped, 0.16 to 0.22 millimeter across. Acetabulum smaller than oral sucker, 0.11 to 0.17 millimeter across, situated in anterior portion of middle third of body length. Mouth subterminal; pharynx, 0.07 to 0.09 millimeter across, immediately behind oral sucker; œsophagus about 0.05 millimeter long. Intestinal cæca often wider in diameter near point

of origin, reaching to near posterior end of body. Genital pore median, preacetabular.

Testes relatively large, oval (seldom pear-shaped), symmetrical, immediately postacetabular; measure from 0.27 millimeter by 0.13 millimeter to 0.34 by 0.16 in size. Cirrus sac pear-shaped, median, immediately preacetabular, from 0.11 millimeter by 0.09 millimeter to 0.15 by 0.11 in size; incloses the much-coiled seminal vesicle, pars prostatica, and cirrus.

Ovary round to oval, median, immediately posttesticular, 0.09 to 0.14 millimeter across. Shell gland distinct, of about the same shape and size as ovary and situated behind that organ. Receptaculum seminis and Laurer's canal present. Uterus in transverse coils behind testes, partly overlapping intestinal cæca and reaching posteriorly beyond blind terminations of latter. Vitellaria in distinct rounded follicles, extending from middle or posterior level of ovary to about 0.30 to 0.34 millimeter from posterior end of body. Transverse vitelline ducts unite to form a roundish vitelline reservoir lying dorsal to shell gland. Eggs oval, operculated, yellowish brown in color, 0.026 millimeter by 0.016 millimeter in size.

Excretory pore median, posterodorsal. Excretory bladder narrow; divides into two lateral branches in the region of shell gland, each lateral branch in turn dividing into anterior and posterior vessels.

Host.—*Scutophilus temminckii* (Horsfield).

Location.—Small intestine.

Locality.—Los Baños, Laguna Province, Luzon.

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ILLUSTRATIONS

ABBREVIATIONS

ac, acetabulum.
an, anus.
cir, cirrus.
cp, cirrus pouch.
cs, cirrus sac.
eb, excretory bladder.
ep, excretory pore.
gp, genital pore.
int, intestine.
lc, Laurer's canal.
od, oviduct.
oes, œsophagus.
oo, oötype.
os, oral sucker.
ov, ovary.
ph, pharynx.
pph, prepharynx.
rs, receptaculum seminis.
sg, shell gland.
sp, spines.
t, testis.
ut, uterus.
vag, vagina.
vd, vitelline duct.
ve, vas efferens.
vg, vitelline gland.
vr, vitelline reservoir.
vs, vesicula seminalis.

PLATE 1

FIG. 1. *Opecoelus minimus* sp. nov., ventral view.
2. *Opecoelus minimus* sp. nov., ventral view showing details of excretory system.
3. *Metadena microvata* sp. nov., ventral view.
4. *Azygia pristipomai* sp. nov., ventral view.

PLATE 2

FIG. 1. *Glyptelmins staffordi* sp. nov., ventral view.
2. *Pleurogenes taylori* sp. nov., ventral view.
3. *Pleurogenes taylori* sp. nov., ventral view showing details of excretory system.
4. *Postorchigenes ovatus* g. et sp. nov., ventral view.

PLATE 3

FIG. 1. *Paradistomum magnum* sp. nov., ventral view.
2. *Metorchis caintaensis* sp. nov., ventral view.
3. *Metorchis caintaensis* sp. nov., median section through anterior part of body.

PLATE 4

FIG. 1. *Leucochloridium dasylophi* sp. nov., ventral view (mature form).
2. *Leucochloridium dasylophi* sp. nov., ventral view (immature form).
3. *Harmostomum* sp., ventral view.
4. *Stomylotrema rotunda* sp. nov., ventral view.

PLATE 5

FIG. 1. *Lecithodendrium ovimagnosum* Bhalerao, 1926; ventral view.
2. *Lecithodendrium luzonicum* sp. nov., ventral view.
3. *Lecithodendrium luzonicum* sp. nov., female reproductive system in ventrolateral aspect.
4. *Platynosomum philippinorum* sp. nov., ventral view.

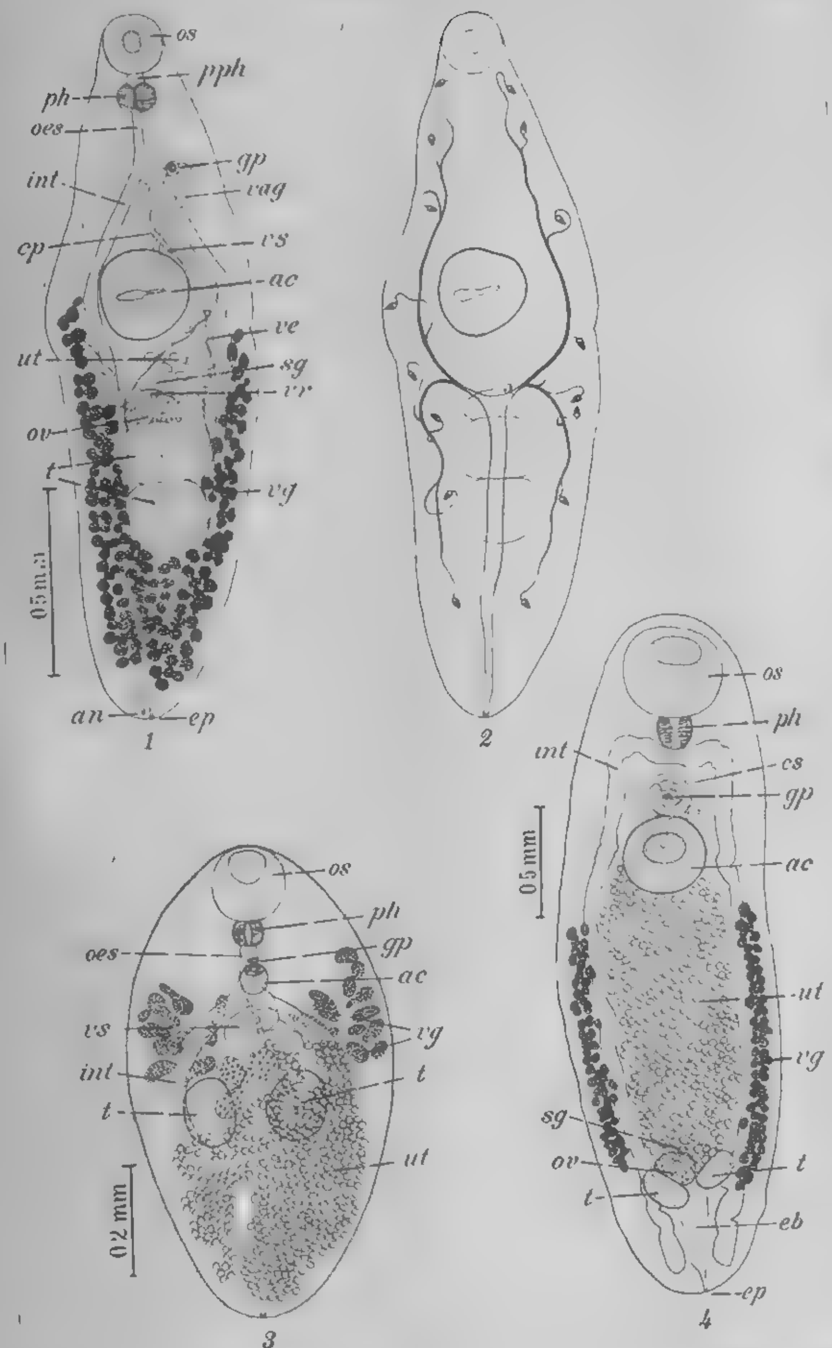
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PLATE 1.

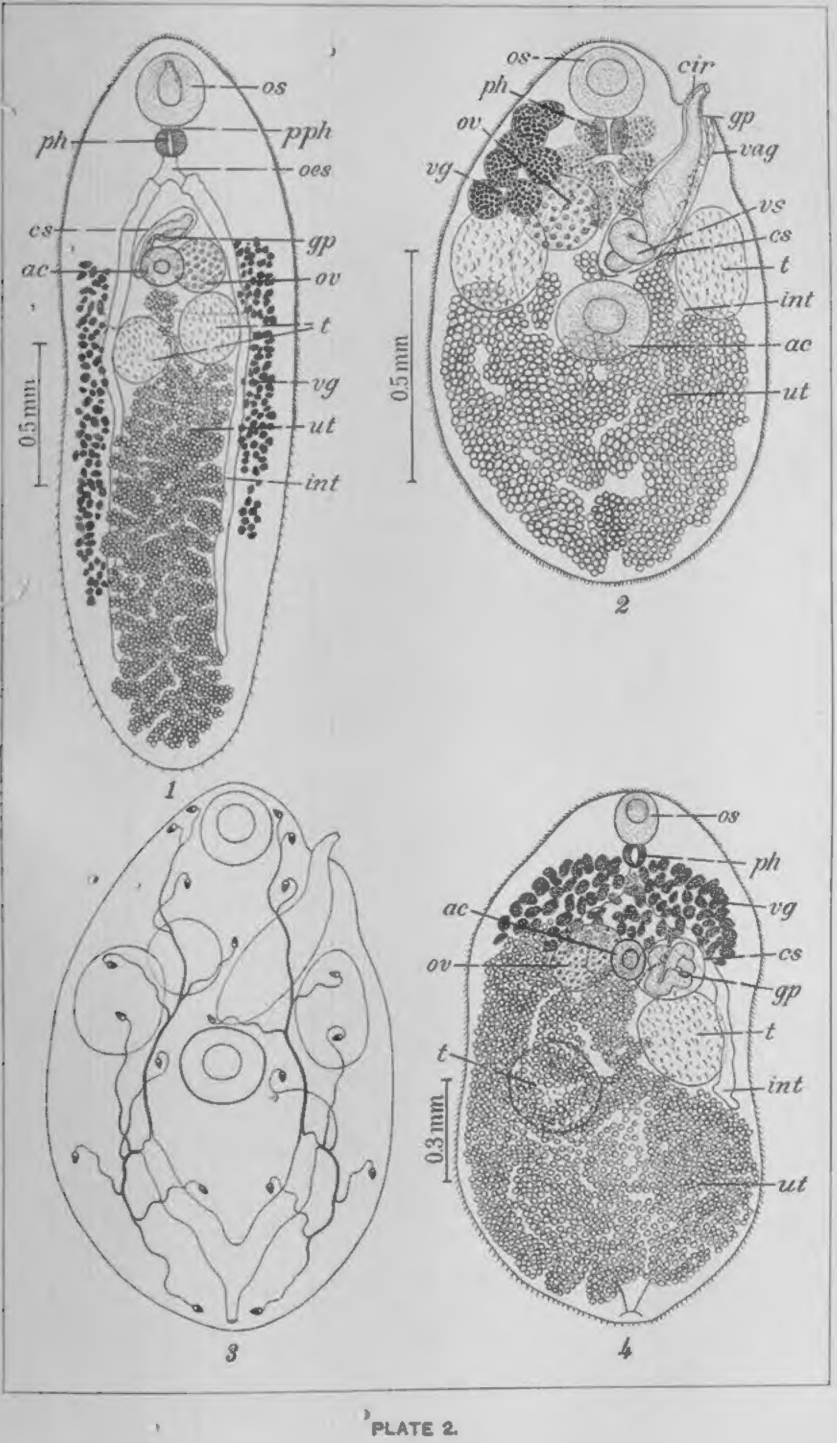
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PLATE 2.

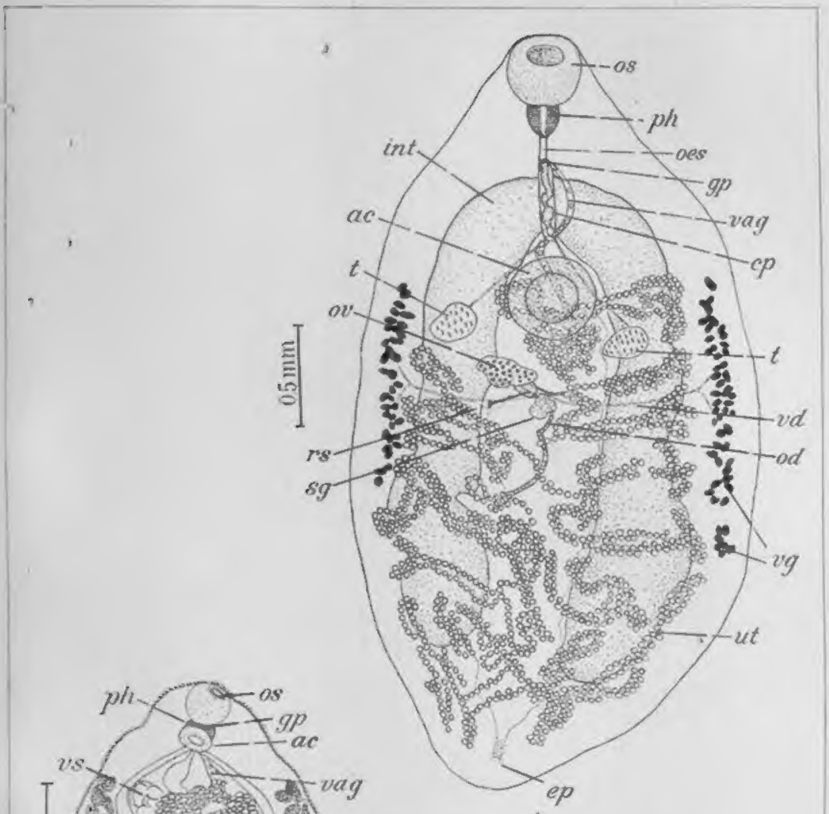
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PLATE 3.

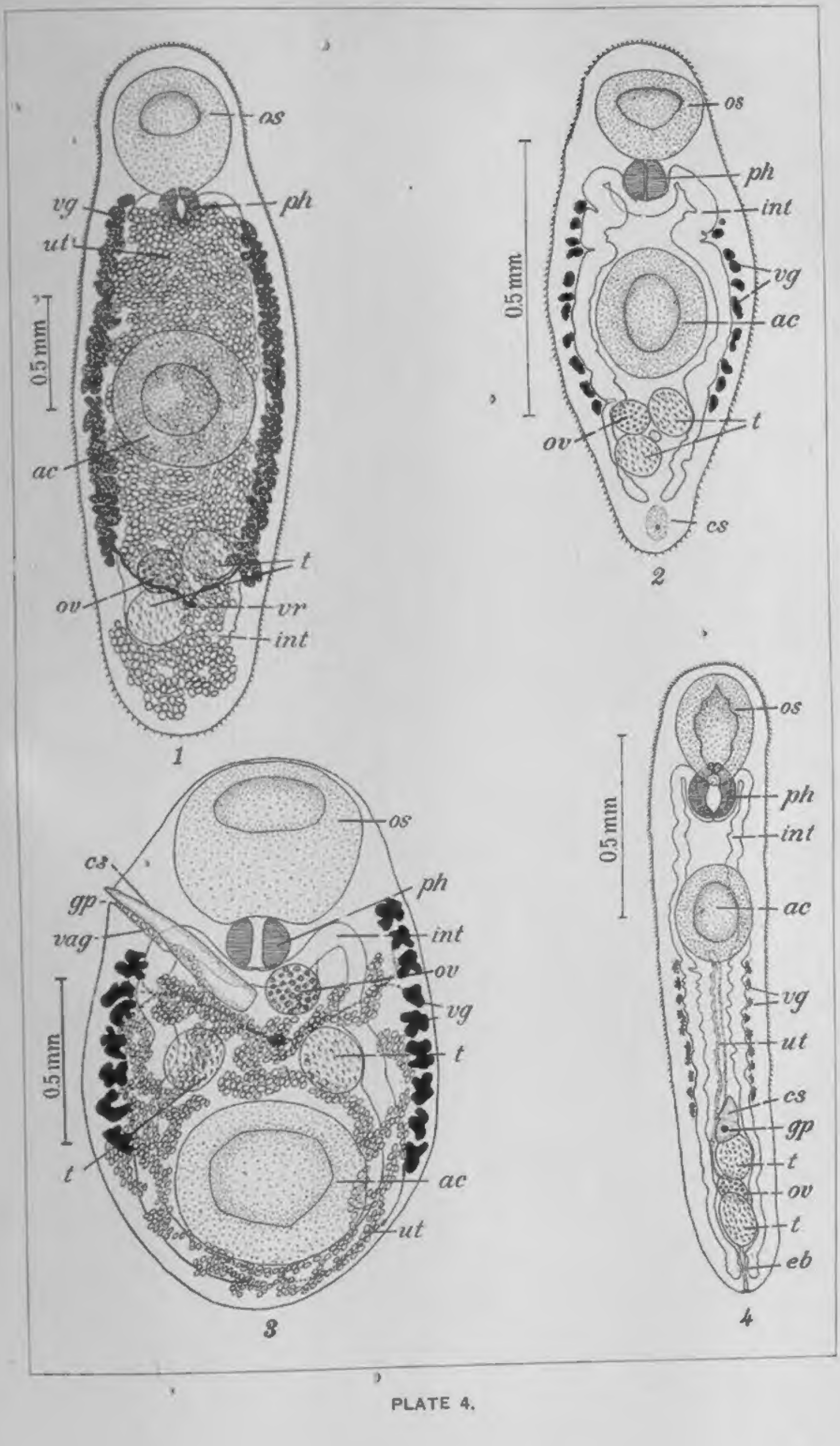
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PLATE 4.

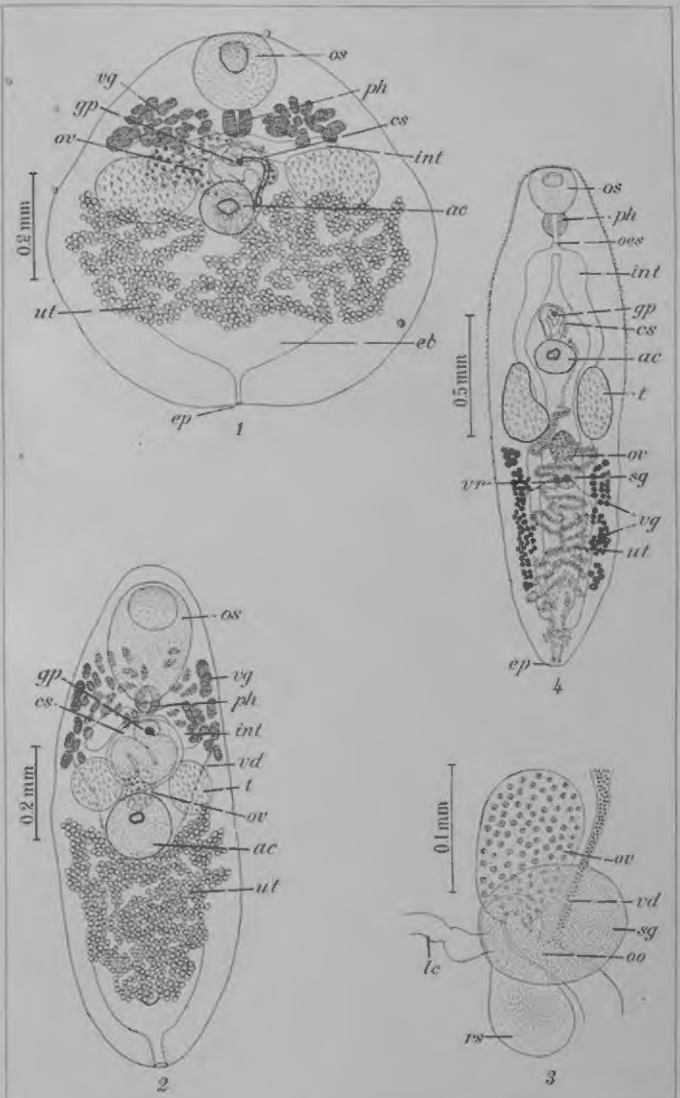
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PLATE 5.